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EDITORIAL

CANCER

On February 12, having received the advice of the Standing Advisory Committee on Cancer and Radiotherapy, the Minister of Health made a statement in Parliament on smoking and cancer of the lung, which gave rise to great concern amongst the people. The crux of his statement was that on statistical evidence there was a relationship between smoking and cancer of the lung. He went on to state that though there is a strong presumption that the relationship is causal there is evidence that it is not a simple one, since:—

(1) the evidence of the presence in tobacco smoke of a carcinogenic agent is not yet certain;

(2) that it is unlikely that the increase in incidence is due entirely to increases in smoking;

(3) the difference in incidence between urban and rural areas and between different towns suggests that other factors may be operating; i.e. atmospheric pollution and occupational risks.

He pointed out also that no immediate dramatic fall in the death rates could be expected if smoking ceased since the development of lung cancer may be the result of factors operating over many years.

It is no wonder that this news was the cause of concern, for of all the ills which assail the human body there is none which excites more apprehension or dread than that which is called cancer.

Malignant growths do not make some sudden attack, as do many of the

(The March issue of The British Veterinary Journal was published on March 8)

infective processes, which call for an immediate and often successful therapeutic response. They work in the dark, establish their claim in a gradual insidious manner and frequently they are firmly established and have propagated their seed in other parts of the body before the host can be aware of their presence. All too often, when a malignant growth is disclosed it is too late to stay its course, other than for a short period of time, no matter what the physician or surgeon may contrive.

Tumours, malignant or benign, are composed of the tissues of the host. It might be said in the case of the malignant or cancerous tumours that they are made up of rebel cells which have deviated from the normal course in their relationship to one another and also to their neighbours in the surrounding tissues.

The form of normal cells is so constant that one can easily recognise any aberration in architecture, in growth, or in relationship to their surroundings. They do not stray from their preordained course or custom. In the case of malignant tissue the cells violate these rules, they assume abnormalities in form, they cast aside the regular motions of growth, their functional activity is often enhanced and in their exuberance they invade neighbouring sites and discharge into the lymphatic and circulating systems so that they may seed and grow in distant parts of the body.

It is this quality or ability to invade other parts of the body which entitles them to the name " malignant," for by doing this they can disorganise completely the normal metabolism of the host and so disturb the functional activity of organs that life is in peril. It is as if the cells acquire some inherent motive power. Extension and metastases are the clinical signs of malignancy. Why and how do new growths acquire these two malevolent properties? The fault may be in the host or it may be centred in the growth. As regards the host there is more than a suspicion that certain types of malignant growth seem to be influenced by genetic factors and some observers are of the opinion that the body can exhibit a considerable resistance to invasion and that the cases which do come under the surveillance of the physician represent nature's failures.

As regards the tumour, one's thoughts turn first to its nutrition. New growths seem to favour sites which are endowed with a good circulatory supply, for the parasite depends on the host for its nutrition. Any part of the body could satisfy this requirement, but some sites are better than others. If the fault lay in the host it would be reasonable to expect a series of primary centres to originate in various parts, and at one and the same time. As far as we know this does not occur. The initiative or urge to malignancy must be something inherent in the tumour itself which causes cells, which have originated from perfectly normal ancestors, to a metabolic riot and contravention of all natural law.

This is the problem which has to be solved. It has occupied the attention of competent workers for many years, but a true and consistent solution evades us. Much fundamental knowledge of great value has accrued. We do know that some malignant growths are associated with trauma and that some clinical substances possess carcinogenetic properties. There is evidence that the exciting

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factor in other instances may be some vital organism of the nature and character of a virus and in the case of transplantable tumours this notion has considerable support, for there is evidence that a degree of immunity can be provoked in the host.

A neuro-endocrine hypothesis has received attention and the reports of the control of malignant disease of the prostate and of the mammary gland by the use of synthetic œstrogens and androgens has shed a great ray of hope on an expectant world. In recent years the discovery of a hormone, in the anterior part of the pituitary, which has a profound influence on growth, has led to further research. It has been found that a neoplasm, if it is to continue to grow, requires the assistance of a normal functioning anterior pituitary gland. Hormones such as stilbœsterol and testosterone inhibit the secretion of these anterior pituitary products, and this explains in some measure the controlling effects they exert upon the growth and extension of certain malignant neoplasms.

The logical sequence of this discovery was to perform hypophysectomy on suitable cases. In one case reported in *Time,* February 1, such an operation was performed upon a woman suffering from recurrent mammary cancer. Hormone replacement therapy was practised. It is said that after a year 95 per cent of the outward signs of cancer had disappeared.

One swallow does not make a summer, but it does tend to dispel the despondency of the winter and bring hope of better things to come. It may be that the tremendous efforts of our research workers have led us to the edge of the horizon. We should redouble our efforts to help and encourage them. Veterinary surgeons have unique opportunities to study the problems of malignant disease and they should do all they can to help the research work which is being so actively pursued in so many centres, both veterinary and medical. In their own practices they should not scorn the empirical approach which is based on trial and error. The great admiral, Lord Fisher, said that the way to win a battle against a stubborn foe was to hit first, hit hard and hit anywhere. Let us all do our utmost to follow this great exhortation.

GENERAL ARTICLES

STUDIES ON THE HÆMATOLOGY OF CALVES FROM BIRTH TO ONE YEAR OF AGE

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A STUDY has been made of the blood picture of normal healthy calves from the time of birth to the age of one year. There is a scarcity of information on the subject, although references have been made by Fraser (1930) and Blount (1939) who dealt mainly with erythrocyte and leucocyte counts and with cellular morphology. Fraser in addition gave hæmoglobin percentages. The observations herewith recorded concern the blood picture of 233 calves all of which were apparently healthy and were from attested herds. They comprised Ayrshires 98, Jerseys 47, Shorthorns 41, Guernseys 39 and Fresians 8.

Blood samples were taken as soon after birth as possible and recordings were made on the different calves at weekly intervals. The number bled each time varied from four to seven. Most of the bleedings were made between the months of March and November and 80 per cent of the calves were at pasture; it was, however, necessary to bleed calves at other periods throughout the year. The ranges of the observations herewith recorded should form a basis for similar observations made on ailing calves.

Techniques

The methods employed are well known and a brief mention only is made of the physical and cytological techniques.

Bleeding. All samples of blood were taken from apparently healthy calves in attested herds and great care was taken not to cause the calf any excitement in order to avoid abnormal readings due to the so called " alarm factor." Two samples of blood were taken from the jugular vein at each bleeding. One sample was not mixed with an anticoagulant and was used for ascertaining the coagulation time and for preparing slides for cell measurements and differential counting. The other sample contained potassium oxalate and ammonium oxalate 4 : 6 to prevent coagulation and was used for the other tests.

Coagulation Time. This test was carried out immediately on collecting the blood. Blood was sucked up into a capillary tube of 1 mm. in diameter; one end was sealed with plasticine and the charged tube placed in a thermos flask containing water at 39° C. Small portions of the tube were broken off at half minute intervals until a thread of fibrin was observed between the broken portions of the tube.

Fragility of Erythrocytes. 5 c.mm. of the oxalated blood was added to each of a series of tubes containing 3 c.c. of different concentrations of 1 per cent sodium chloride in distilled water; the variations between each tube were 0.05 per cent. The tubes were inverted and allowed to stand at room tempera-

ture for 24 hours. The tube containing the highest percentage of sodium chloride and in which complete hæmolysis first occurred was noted, and the percentage concentration of sodium chloride in that tube was taken to indicate the fragility index of erythrocytes.

The Blood Sedimentation Rate. The method used for this test was that described by Wintrobe (1951). The hæmatocrit tubes were allowed to stand vertically for 24 hours as no appreciable readings are obtained with bovine blood until 24 hours have elapsed. The amount of sedimentation is recorded in millimeters.

The Packed Cell Volume. Anticoagulants have an effect on the packed cell volume and for this reason several workers have centrifuged bovine blood at different speeds for varying periods of time, according to the anticoagulant used. It has been found in this laboratory that using Wintrobe's potassium and ammonium oxalate combination a constant packed cell volume could be obtained by centrifuging the blood in the hæmatocrit tubes for 1 hour at 3,000 r.p.m.

Hæmoglobin Estimations. Hæmoglobin estimations were made using a M.R.C. Grey Wedge Photometer. The readings obtained were the percentage hæmoglobin on the Haldane Scale and these were converted into grams of hæmoglobin per 100 ml. of blood by reference to the scale appropriate to that particular instrument.

The Erythrocyte Count. Erythrocyte counts were made by diluting the blood 1/200 with 3 per cent sodium citrate to which 1 per cent formalin had been added. Dilutions were made with a Thoma pipette and a hæmocytometer with Neubauer rulings was used, counting 64 squares. Two counts were made and any error of 10 per cent or more necessitated a recount.

Blood Platelets. These were counted in the unstained state after the erythrocyte count had been made. There is a considerable degree of experimental error in any method employed for counting blood platelets, but the figures obtained gives a picture of the range for calves during their first year of life.

Leucocyte Counts. The blood was diluted 1 :20 with Gurr's white cell diluting fluid using a Thoma pipette. A hæmocytometer with Neubauer rulings was used and two areas of 1 sq. mm. on either side of the central channel were counted. A difference of more than 10 per cent between the two sides necessitated a recount.

Differential Counts. Films were prepared from non-oxalated blood and treated with Leishman's stain. 200 cells were observed on each slide by counting straight across the slide approximately in the centre of the smear. (See Dacie, 1950). Differential counts were not made on some of the calves because of the unsuitability of the blood films.

Size of Cells. All cell measurements were made with a micrometer scale inserted into the eyepiece of the microscope. The cell measurements are given in microns.

Results

A total of 233 calves were bled over the period of twelve months. The number in each month during the period under investigation was:—

Years 1952-1953

Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.
13	2	10	15	18	19	13	38	32	28	34	11

Of this total 182 were bled whilst at pasture. On some occasions calves of the same age were bled under housed and pastured conditions, but apart from erythrocyte counts which will be explained later, there was no significant difference in the results obtained from each calf. It will be noticed in the tables which follow, that the number of calves do not always total 233; this is explained by the fact that, owing to technical difficulties, it was not always possible to carry out a particular test on all the calves.

Coagulation Time. Coagulation times varied from 2 minutes (43-week-old calf) to 11 minutes (26 weeks) and the frequency distribution is given in Table I. Over the 52 week period the coagulation time for the majority of the calves was between 3 and $7\frac{1}{2}$ minutes. It would appear from Fig. 1, which gives the

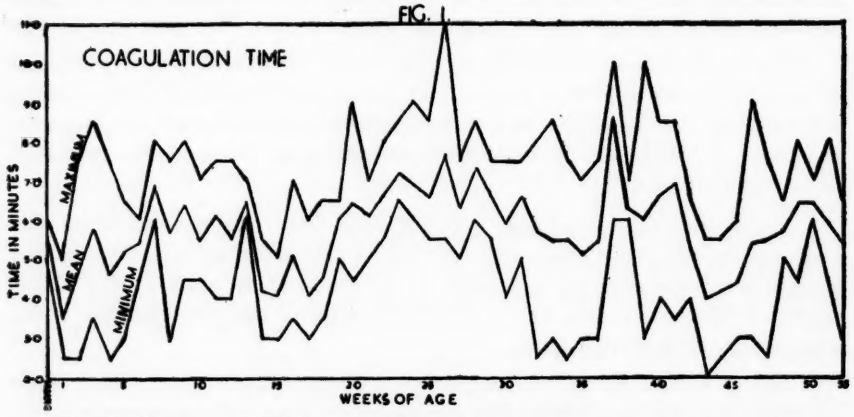
TABLE I

Coagulation Times of Calves

Minutes	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
No. of calves	1	6	15	11	13	12	19	26	30	28	19

Minutes	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	
No. of calves	23	8	8	4	1	2	0	1	Total: 227

FIG. 1



Showing the Average, Maximum and Minimum Coagulation Times at the various age groups.

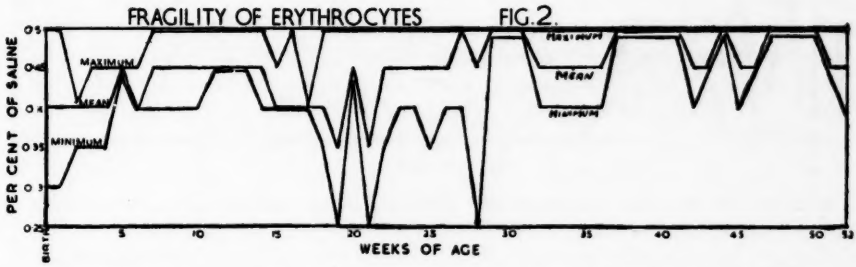
readings according to the ages of the calves, that the coagulation time is much slower between the 20th and 35th weeks than before and after this period.

Fragility of Erythrocytes. The fragility of erythrocytes varies within the range of percentages of saline used, from 0.25 per cent to 0.5 per cent. The low figure of 0.25 per cent was recorded in two calves at 19 weeks and in two at 21 weeks. One calf at 28 weeks gave a similar figure. During the first four weeks of the calf's life the fragility of erythrocytes has a value of between 0.3 per cent and 0.35 per cent and this increases during the next four months to

TABLE II

Fragility of Erythrocytes of Calves

Per Cent of Saline	0.25	0.30	0.35	0.40	0.45	0.50	Total:
No. of Calves	5	2	17	37	37	127	225



Showing the Average, Maximum and Minimum Fragility of Erythrocytes at the various age groups.

between 0.4 per cent and 0.45 per cent. From about the 20th week onwards the value, with few exceptions, is 0.5 per cent.

The Blood Sedimentation Rate. The blood sedimentation rate of the blood of cattle is comparatively much slower than that of humans and of other animals, particularly the horse. In order that an appreciable reading may be obtained, blood from bovine animals should be allowed to stand in a vertical position for at least 24 hours. Ferguson (1937) studied the blood sedimentation rate and packed cell volume of the blood of 22 cows. The blood was allowed to stand for 7 hours but the ages of the animals were between three and eight years and thus a comparison with the observations made upon calves is not possible.

The data given in Table III and Fig. 3 shows that during the period under investigation the blood sedimentation rate ranged from 1.0 mm. to 7.0 mm.;

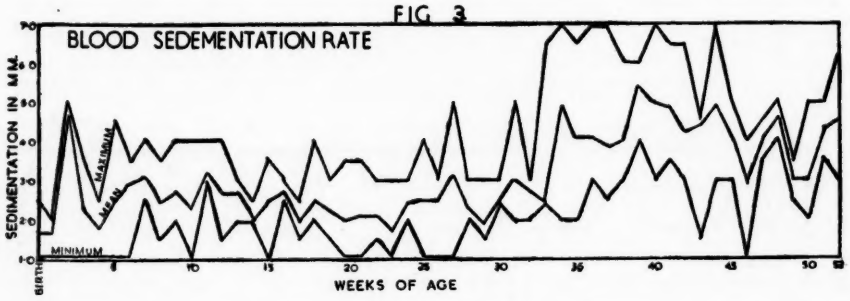
most of the calves up to the 33rd week gave a recording of 1.0 mm. to 3.0 mm. Between the 33rd and 44th weeks the value is higher ranging between 3.0 mm. and 7.0 mm. Twenty of 48 calves gave values of from 5.0 mm. to 7.0 mm. during this period. From the 44th to the 52nd week the rate fell to a range of between 2.5 mm. to 5.0 mm.

TABLE III

Blood Sedimentation Rate of Calves

B.S.R. in mm.	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	Total 233
No. of calves	20	14	43	35	48	18	16	11	8	3	8	4	5	

FIG. 3



Showing the Average, Maximum and Minimum Blood Sedimentation Rates at the various age groups.

Packed Cell Volume. The corpuscular volume varied from 18.0 mm. to 61.0 mm. although most of the calves had values of 30.0 mm. to 50.0 mm. The high value of 61.0 mm. was registered in a four-week-old calf which had a high erythrocyte count of 11.1 million per cent of blood. The packed cell volume bears a close relationship to the erythrocyte count; and this can be seen in the Figures 4 and 6. During the first weeks of life high values occur in both these tests; the hæmoglobin content also being correspondingly high. There appears however, to be a tendency for both the erythrocyte count and the packed cell volume to show decreasing values from about the 28th week—this decrease being more pronounced with the packed cell volume. A similar decrease occurs in

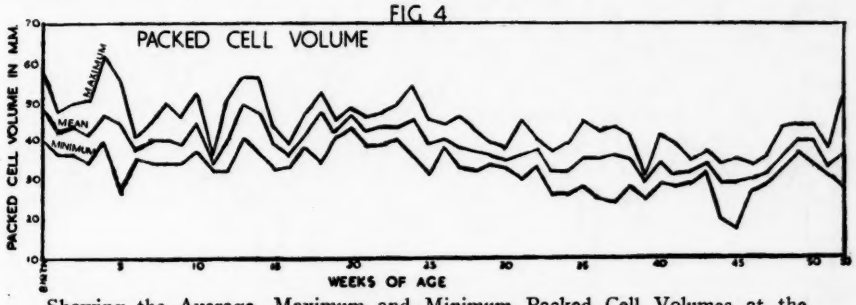
TABLE IV

Packed Cell Volumes of Calves

P.C.V. in mm.	10-20	20.5-30	30.5-40	40.5-50	50.5-60	60.5-70.0	Total 233
No. of calves	2	19	118	81	12	1	

infants at the age of 10 weeks and is attributed to the appearance of smaller corpuscles, but in the calf there appears to be little difference in the size of erythrocytes from birth to 52 weeks as the size ranged from 5μ to 6μ throughout the year.

FIG. 4



Showing the Average, Maximum and Minimum Packed Cell Volumes at the various age groups.

Hæmoglobin Contents. The hæmoglobin content ranged between 4.60 and 16.05 grams per 100 ml. of blood; the majority of calves gave readings of 9.0 to 14.5 grams per 100 ml. Low values of 4.60, 5.50 and 6.30 grams per 100 ml. were recorded in three calves at 35, 14 and 32 weeks of age respectively. The highest value 16.05 grams per 100 ml. was obtained from a calf bled at birth; this calf had an erythrocyte count of 9.1 millions per c.c. of blood and a correspondingly high packed cell volume of 57.0 mm.

TABLE V

Frequency distribution of Hæmoglobin Content in Calves

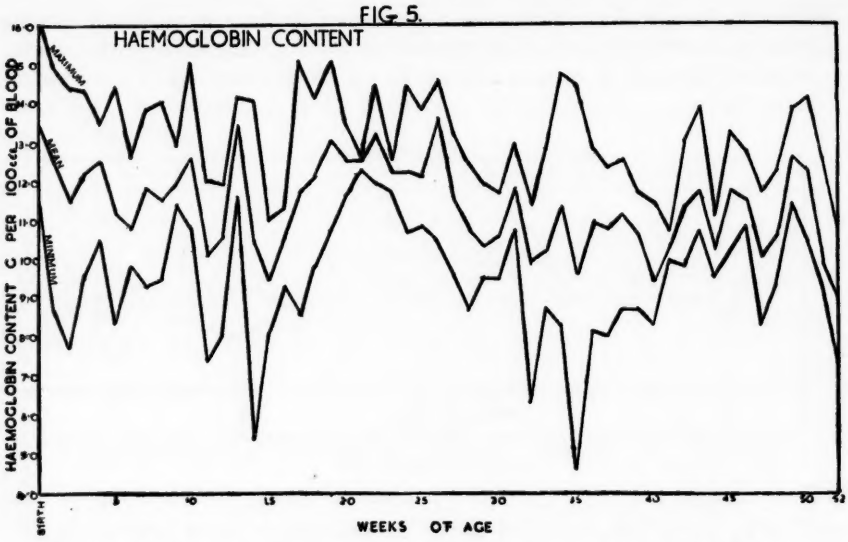
Hb. grams per 100 ml. of blood	4.1-6.0	6.1-8.0	8.1-10.0	10.1-12.0	12.1-14.0	14.1-16.0
No. of calves	2	6	38	102	65	19

Total: 232

It appears from the data given in Table V and Figure 5 that the hæmoglobin content of the calf is high at birth; this decreases during the first two weeks of life and is followed by fluctuations during the remainder of the year. Calves between the ages of four to seven months have higher values than do older calves. Somewhat similar figures are recorded by other authors (Fraser, 1930) and a comparison of the two sets of figures is given below:—

Age	Recorded Mean Figures	Mean Figures of Other Authors (Fraser)
Birth	90.6 per cent	87.0 per cent
1 week	84.0 „ „	73.0 „ „
2-4 months	78.0 „ „	80.0 „ „
4-6 months	84.0 „ „	76.0 „ „
12 months	62.0 „ „	64.0 „ „

FIG. 5.



Showing the Average, Maximum and Minimum Hæmoglobin Content at the various age groups.

The Erythrocyte Count. This count is largely influenced by the age of the animal and high counts are obtained during the first weeks of life. The extreme limits of the erythrocyte count were between 3.1 and 14.7 million per c.mm., but most of the calves had values between 5 and 10 million. Low figures of 3.1 and 3.5 million were recorded in calves of 45 and 46 weeks of age respectively, whereas the high count of 14.7 million was of a calf of 19 weeks of age. Fraser points out, that difficulty is to be expected when comparing age groups, as some of the animals he examined were housed and some at pasture. Animals at pasture had lower counts, and this corresponds with the experience herewith recorded. In general there is a large measure of agreement between his records and those presented here. The comparative figures are:

Age	Recorded Mean Figures	Mean Figures of Other Authors (Fraser)
Birth	7.4 millions per c.mm.	7.9 millions per c.mm.
1 week	7.5 „ „ „	6.2 „ „ „
8-12 weeks ...	8.1 „ „ „	8.0 „ „ „
4-6 months ...	7.8 „ „ „	7.2 „ „ „
12 months ...	7.5 „ „ „	5.3 „ „ „

The high figure at 12 months is accounted for by the fact that one calf gave a count of 10.0 million whilst the three other calves examined at this age had figures of 6.5, 6.8, 6.9 million.

From the results obtained there is little difference between the sizes of erythrocytes during the first 52 weeks of the calf's life. The average size is from

5μ to 6μ with limits of 4μ to 8μ; these figures are within the range given by other authors.

The extremes of the Mean Corpuscular Volume (M.C.V.) were 28 to 112 c. microns whereas the average was from 40 to 60 c. microns and was evenly distributed throughout the first twelve months of life.

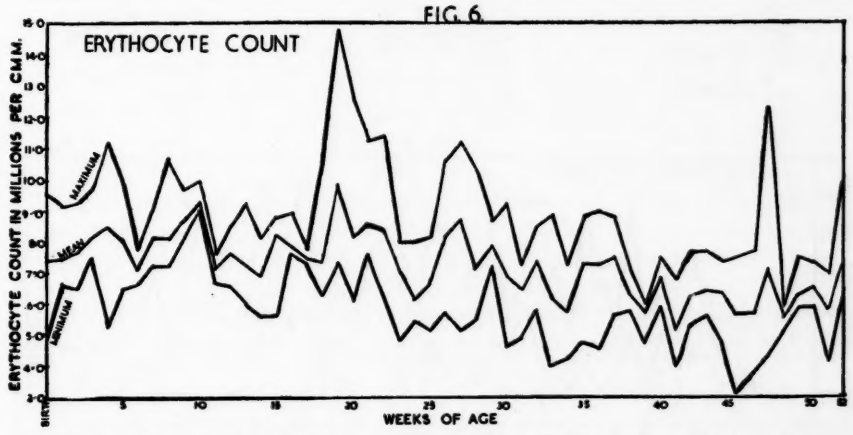
TABLE VI

Frequency distribution of the Erythrocyte Count

No. of calves	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	9.1-10.0	10.1-11.4
Millions per c.c.	4	13	37	49	66	34	18	12
			Total: 233					

The Mean Corpuscular Hæmoglobin Concentration (M.C.H.C.) showed little variation, the majority of the calves ranging between 21 and 40 per cent, and graphically this is shown by a line which is almost straight.

FIG. 6.



Showing the Average, Maximum and Minimum Erythrocyte Counts at the various age groups.

Anisocytosis was displayed at the different ages, particularly in the early weeks. Megalocytes were also prominent, whereas only five normoblasts were found after an extensive search of all the smears made from calves up to the age of four weeks. Normoblasts are rarely found in calves bled at frequent intervals from birth to seven days old (Fraser, 1930; Blount, 1939).

No reticulocytes were observed in any of the stained preparations made, although Fraser found 0 to 1.4 per cent of reticulocytes in calves up to two days old; these, however, were not always present even in calves examined a few hours after birth. Punctate basophilia was also absent; Fraser noted the

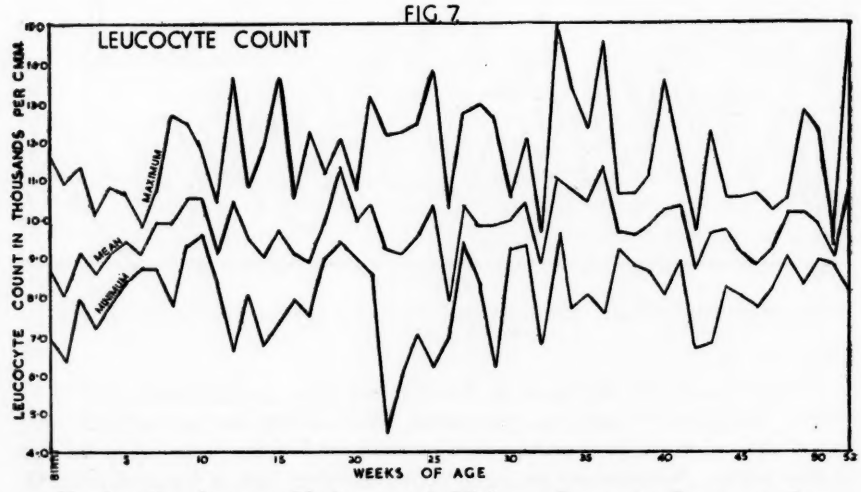
occurrence of this in calves and states " in some it is not present within two hours of birth, and it has not been observed in the blood of healthy calves after 48 hours."

The Platelet Count. This is subject to considerable experimental error but the figures given may be of value as the technique employed was constant and the findings illustrate the range which may be expected in calves' blood. The limits of the count were between 150,000 and 525,000 per c.mm. and most of the calves come within the range of 250,000 and 400,000. One calf of 11 weeks of age had the high count of 764,000 whilst the lowest figure recorded was 100,000 in a calf at 36 weeks of age. The blood platelets of the calf appear to be much larger than those of the adult and can be identified easily.

The Leucocyte Count. The number of leucocytes per cubic millimeter of blood ranged between 4,500 and 15,000 with the common range of 6,500 to 11,500 per c.mm. There is a slight difference between these figures and those obtained by Fraser.

Age	Recorded Mean Figures	Mean Figures of Other Authors (Fraser)
Birth	8,700 per cm.	10,000 per cm.
2-4 months ...	9,700 „ „	8,500 „ „
4-6 months ...	9,300 „ „	9,200 „ „

FIG. 7



Showing the Average, Maximum and Minimum Leucocyte Counts at the various age groups.

Counts of over 10,000 in animals 12 months and over were not recorded by Fraser but of the four calves examined at this age, counts of 14,500, 11,600 9,200 and 8,200 were obtained.

TABLE VII

Frequency distribution of the Leucocyte Count

No. of Leucocytes per thousand	4-5.0	5.1-6.0	6.1-7.0	7.1-8.0	8.1-9.0	9.1-10.0	10.1-11.0
No. of calves	1	1	14	24	44	54	50

No. of Leucocytes per thousand	11.1-12.0	12.1-13.0	13.1-15.0	
No. of calves	19	18	8	Total: 233

The Neutrophil Leucocytes. "Young" forms were rare throughout the investigation and "Band" forms represented only about 4 per cent to 5 per cent of the total number of neutrophils seen; recordings given include both the young and band forms. The figures obtained over the 52 week period were so variable that no marked variation curve could be obtained. The limits of the neutrophil count were from 6 per cent to 64 per cent with an average of 25 per cent. These figures agree with those of Fraser although he obtained a much higher percentage up to the first week of life.

Age	Recorded Mean Figures	Mean Figures of Other Authors (Fraser)
Birth	45.0 per cent	61.1 per cent
1 week	32.0 „ „	40.4 „ „
2-4 months	37.0 „ „	31.8 „ „
4-6 months	21.7 „ „	21.6 „ „
52 weeks	27.7 „ „	30.3 „ „

The average size of the neutrophil was from 10μ to 12μ with limits of from 9μ to 14μ.

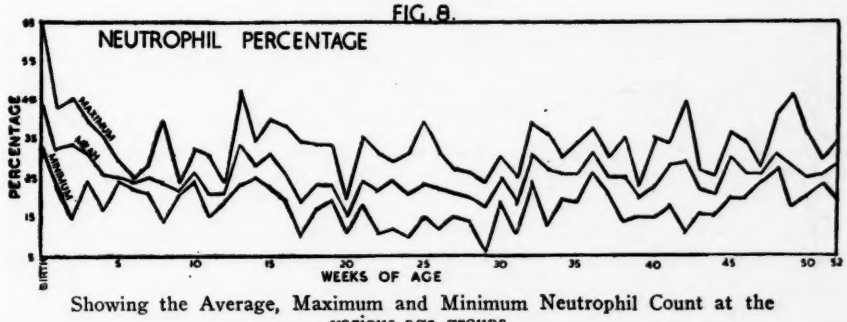
TABLE VIII

Frequency distribution of Neutrophil Leucocyte Percentage

Percentage of Neutrophils	6-10	11-20	21-30	31-40	41-50	51-60	61-70
No. of calves	3	64	107	45	7	1	1

Total: 228

FIG. 8.



Showing the Average, Maximum and Minimum Neutrophil Count at the various age groups.

The Lymphocytes. It was found when estimating the size of lymphocytes that only large and small cells could be differentiated with any accuracy, although some cells came between these two extremes. Blount (1939) divided lymphocytes into three classes, namely large, medium and small, and stated that medium sized lymphocytes were common in the calf. The size of the *small* lymphocytes varied from 7μ to 10μ compared with Blount's figures of 7.9μ to 8.9μ and Fraser's of 3μ to 10μ. Large lymphocytes ranged between 11μ and 12μ, whereas Blount gave figures of 12μ to 14μ and Fraser 13μ to 15μ.

TABLE IX

Frequency distribution of Lymphocyte Percentage

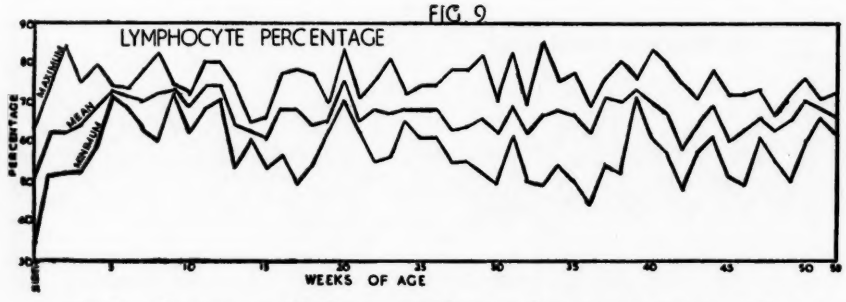
Percentage of lymphocytes	30.40	41.50	51.60	61.70	71.85
No. of calves	2	8	35	101	82

Total: 228

The numbers of lymphocytes over the 52 weeks ranged between 34 to 85 per cent. Fraser records low counts at birth with a considerable rise after the first day. This differs from the experience herewith recorded, as the average of the six calves bled at birth was 50.8 per cent, which is nearly twice the average of Fraser's calves. A much higher figure was also obtained for the calves at one week. A comparison is made between the percentages obtained with those observed by Fraser.

Age	Recorded Mean Figures	Mean Figures of Other Authors (Fraser)
Birth	50.8 per cent	29.2 per cent
1 week	62.5 „ „	39.2 „ „
2-4 months	68.6 „ „	61.2 „ „
6 months	68.2 „ „	70.9 „ „
12 months	67.0 „ „	61.2 „ „

FIG. 9



Showing the Average, Maximum and Minimum Lymphocyte Counts at the various age groups.

The Monocytes. Some difficulty is experienced in differentiating monocytes from large lymphocytes and in doubtful cases the cell was recorded as a lymphocyte. The sizes of the monocytes ranged from 10μ to 18μ and most of them were from 12μ to 14μ. The percentage of monocytes ranged from 0 per cent to 12 per cent with an average of 3.6 per cent. The distribution of monocytes over the 52 weeks appears from the figures obtained to be divided into three phases:

TABLE X

Frequency distribution of Monocyte Percentage

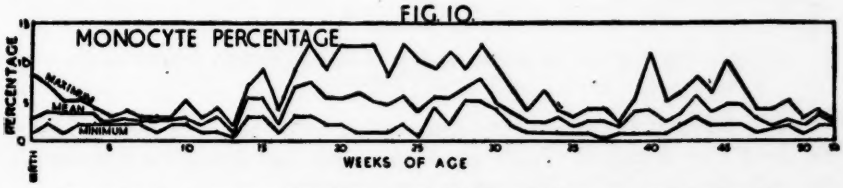
Percentage of monocytes	0-5	6	7	8	9	10	11	12
No. of calves	182	11	8	13	5	2	2	5

Total: 228

(a) low counts of 0 per cent to 5 per cent from birth to 16 weeks; (b) high counts of 0 per cent to 12 per cent at the age of 16 to 28 weeks; (c) low counts of from 0 per cent to 5 per cent (with few exceptions) from 28 to 52 weeks of age. Fraser recorded high counts during the first week of life but these were not observed in this series, in fact the monocyte percentages obtained throughout were much lower as seen in Table X. This may be accounted for by the fact that Fraser included both small and large monocytes in his figures and it is highly probable that in this survey some of the small monocytes were recorded as lymphocytes. The figures obtained by Fraser are compared.

Age	Recorded Mean Figures	Mean Figures of Other Authors (Fraser)
Birth	2.8 per cent	6.3 per cent
1 week	3·7 „ „	19·5 „ „
2-4 months	3·4 „ „	6.2 „ „
4-6 months	5·7 „ „	6.7 „ „
52 weeks	2.2 „ „	5.6 „ „

FIG. 10.



Showing the Average, Maximum and Minimum Monocyte Counts at the various age groups.

The Eosinophil Leucocytes. The *sizes* of the eosinophils observed corresponded closely with those recorded by other workers and had a range of 8μ to 15μ; most measured from 10μ to 12μ. No attempt was made to classify the eosinophils. The percentage number of eosinophils varied from 0 to 15 and

very few of these cells were found during the first 16 weeks of life. Eosinophil counts were made on calves at daily intervals during the first week of life and it is clear that a calf has a higher count at birth than during the succeeding seven days. As the age of the calf increased the tendency then is for the eosinophil count also to increase. In some cases counts of from 12 per cent to 15 per cent were obtained and where these high counts were recorded fæcal samples were examined for helminthiasis; the results were negative in all cases.

TABLE XI

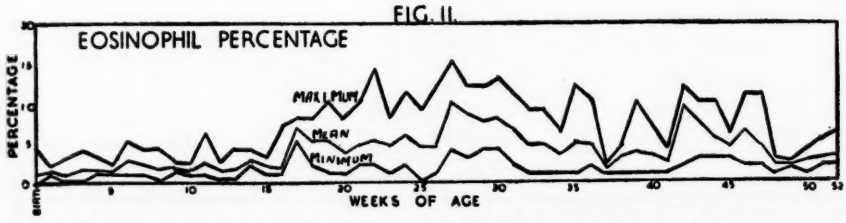
Frequency distribution of Eosinophil Percentage

Percentage of Eosinophils	0-5	6-10	11-15	
No. of calves	169	42	17	Total: 228

The figures obtained were higher than those published by Fraser with which they are compared.

Age	Recorded Figures Min.	Max.	Av.	Other Authors (Fraser) Min.	Max.	Av.
Birth ...	0 p.c.	4 p.c.	1.1 p.c.	0 p.c.	1.4 p.c.	0.4 p.c.
1 week ...	1 „	2 „	1.5 „	0 „	0.2 „	0.03 „
2-4 months ...	1 „	7 „	1.9 „	0 „	3.0 „	0.7 „
4-6 months ...	1 „	14 „	4.9 „	0 „	1.6 „	0.8 „
52 weeks ...	2 „	6 „	3.0 „	1 „	3.4 „	1.8 „

FIG. II.



Showing the Average, Maximum and Minimum Eosinophil Counts at the various age groups.

The Basophil Leucocytes. No basophil leucocytes were observed in any of the blood films examined. Fraser recorded 0.3 per cent during the first week of the calf's life but failed to find any at 4 to 6 months.

Summary

The hæmatological picture of 233 apparently normal healthy calves from attested herds has been studied. The calves were bled at birth and at weekly intervals for the first 52 weeks of life. This survey was carried out to ascertain the normal variations which occur in calves' blood during their first year of life

and to serve as a basis for comparisons to be made with the blood of diseased calves.

Fraser (1930) also studied the blood of calves making particular reference to erythrocyte and leucocyte counts, hæmoglobin estimations and cellular morphology and comparisons have been made with his and other authors' works. Additional observations have been made on the coagulation time, fragility of erythrocytes, blood sedimentation rates, and packed cell volumes, as it is thought that these tests also may assist in future investigations.

The techniques employed have been described and the changes recorded throughout the year have been discussed under the various tests performed.

Acknowledgments

The writer wishes to express his thanks to Professor Burrow for placing the facilities of the Department of Medicine at his disposal and for the help and advice given in many ways; also to the farmers in the College practice at Wallingford for allowing access to the calves. Particular thanks are due to Miss S. A. Bunce, technician, for her invaluable assistance with much of the technical work, for keeping the records of the calves bled and for preparing the figures and tables.

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See following Tables on pages 134—138.

Age of Calves in Weeks	No. of Calves Bled		Coagulation Time (Minutes)	Fragility of Erythrocytes (% Saline)	Blood Sedimentation Rate (mm.)	Packed Cell Volume (mm.)	Hæmoglobin Content (G. per 100 cc.) of Blood	Erythrocyte Count (Millions per cmm.)	Tota Leucocyte Count	Platelet Count (Thousands)	Neutrophils (per cent.)	Lymphocytes (per cent.)	Monocytes (per cent.)	Eosinophils (per cent.)	Mean Corpuscular Volume (c. microns)	Mean Corpuscular Hæmoglobin Concentration (per cent.)
Birth	6	Mean	5·6	0·4	1·7	48·5	13·40	7·4	8·700	286	45·0	50·8	2·8	1·2	67·3	27·3
		Min.	5·0	0·3	1·0	40·0	11·60	4·9	6·900	170	33	34·0	1·0	0·0	58·0	24·0
		Max.	6·0	0·5	2·5	57·0	16·05	9·4	11·600	328	64	63·0	8·0	4·0	90·0	29·0
1 week	5	Mean	3·5	0·4	1·7	42·4	12·45	7·5	8·000	386	32	62·5	3·7	1·5	55·6	29·4
		Min.	2·5	0·3	1·0	36·0	8·75	6·7	6·400	208	23	51·0	2·0	1·0	46·0	24·0
		Max.	5·0	0·5	2·0	47·0	14·90	9·1	10·900	398	43	74·0	7·0	2·0	68·0	33·0
2 weeks	4	Mean	4·7	0·4	4·6	43·0	11·55	7·7	9·100	325	33	62·2	3·2	1·0	55·5	27·5
		Min.	2·5	0·35	1·0	36·0	7·70	6·4	7·900	218	15	52·0	1·0	0·0	52·0	17·0
		Max.	7·5	0·4	5·0	49·0	14·45	9·2	11·300	435	45	84·0	5·0	3·0	61·0	32·0
3 weeks	5	Mean	5·8	0·4	2·3	41·4	12·20	8·2	8·600	392	31	64·6	3·2	1·8	49·8	30·4
		Min.	3·5	0·35	1·0	34·5	9·65	7·4	7·200	210	22	52·0	2·0	0·0	46·0	28·0
		Max.	8·5	0·45	3·5	50·5	14·30	9·6	10·100	566	39	75·0	5·0	4·0	53·0	33·0
4 weeks	6	Mean	4·6	0·4	1·8	46·4	12·50	8·5	9·100	371	26	68·8	3·1	1·8	56·0	27·3
		Min.	2·5	0·35	1·0	39·0	10·55	5·2	7·800	220	17	58·0	2·0	1·0	44·0	22·0
		Max.	7·5	0·45	2·5	61·0	13·55	11·1	10·800	487	35	79·0	4·0	3·0	75·0	30·0
5 weeks	4	Mean	5·2	0·45	2·4	44·0	11·25	8·1	9·400	416	25	73·0	2·3	1·6	53·2	26·2
		Min.	3·0	0·45	1·0	28·0	8·30	6·4	8·400	216	22	72·0	2·0	1·0	44·0	25·0
		Max.	6·5	0·45	4·5	55·0	14·40	9·8	10·600	590	29	74·0	3·0	2·0	61·0	29·0
6 weeks	4	Mean	5·4	0·4	2·9	38·5	10·90	7·1	9·100	384	24	71·0	2·7	2·7	53·0	28·0
		Min.	4·5	0·4	1·0	35·0	9·80	6·6	8·700	334	20	68·0	2·0	1·0	46·0	25·0
		Max.	6·0	0·45	3·5	41·0	12·65	7·6	9·800	480	25	73·0	4·0	5·0	60·0	31·0
7 weeks	4	Mean	6·9	0·45	3·1	40·4	11·85	8·1	9·900	425	25	70·5	2·5	2·2	51·7	29·2
		Min.	6·0	0·4	2·9	34·0	9·35	7·3	8·700	312	19	63·0	2·0	1·0	46·0	27·0
		Max.	8·0	0·5	4·0	44·5	13·85	9·0	10·700	486	28	78·0	3·0	4·0	58·0	33·0
8 weeks	4	Mean	5·7	0·45	2·5	40·4	11·50	8·1	9·900	377	24	72·0	2·5	1·5	50·2	29·2
		Min.	3·0	0·4	1·5	34·0	9·50	7·3	7·800	290	14	60·0	1·0	0·0	36·0	25·0
		Max.	7·5	0·5	3·5	49·5	14·00	10·5	12·600	462	39	82·0	3·0	4·0	61·0	37·0
9 weeks	4	Mean	6·4	0·45	2·7	39·4	12·05	8·7	10·500	350	23	73·0	2·6	2·0	45·0	30·7
		Min.	4·5	0·4	2·0	34·5	11·45	8·1	9·300	156	22	72·0	2·0	2·0	37·0	25·0
		Max.	8·0	0·5	4·0	46·0	12·95	9·6	12·400	506	23	74·0	3·0	2·0	52·0	35·0
10 weeks	4	Mean	5·5	0·45	2·3	44·5	12·65	9·3	10·500	411	26	69·0	3·0	1·5	47·7	28·2
		Min.	4·5	0·4	1·0	37·0	10·80	9·0	9·600	364	24	62·0	2·0	1·0	40·0	27·0
		Max.														

XUM

Max.	8·8	0·5	4·8	46·8	12·95	9·8	12·400	508	23	74·0	3·0	2·0	52·0	33·0	
10 weeks 4 Mean	5·5	0·45	2·3	44·5	12·65	9·3	10·500	411	26	69·0	3·0	1·5	47·7	28·2	
Min.	4·5	0·4	1·0	37·0	10·80	9·0	9·600	364	24	62·0	2·0	1·0	40·0	27·0	
Max.	7·0	0·5	4·0	52·0	15·05	9·9	11·700	422	32	72·0	5·0	2·0	58·0	29·0	
11 weeks 4 Mean	6·1	0·45	3·2	34·4	10·10	7·1	9·100	401	21	74·7	2·0	2·5	48·2	29·5	
Min.	4·0	0·45	3·0	32·0	7·40	6·7	8·300	276	15	68·0	1·0	1·0	45·0	23·0	
Max.	7·5	0·5	4·0	36·5	12·05	7·5	10·400	764	30	80·0	3·0	6·0	54·0	34·0	
12 weeks 4 Mean	5·5	0·45	2·7	40·5	10·60	7·6	10·400	325	21	74·2	3·0	1·5	52·7	26·2	
Min.	4·0	0·45	1·5	32·0	8·15	6·6	6·600	188	19	70·0	1·0	0·0	44·0	24·0	
Max.	7·5	0·4	4·0	50·0	11·90	8·4	13·600	394	24	80·0	4·0	2·0	60·0	29·0	
13 weeks 4 Mean	6·5	0·45	2·7	49·5	13·40	7·3	9·500	245	33	64·5	1·0	1·7	68·7	28·0	
Min.	6·0	0·45	2·0	40·5	11·60	6·0	8·000	170	23	53·0	0·0	0·0	59·0	26·0	
Max.	7·0	0·5	3·0	56·0	14·15	9·2	10·800	330	47	74·0	2·0	4·0	79·0	30·0	
14 weeks 4 Mean	4·2	0·45	2·0	47·0	10·45	6·9	9·000	403	28	63·5	5·2	2·7	68·2	23·0	
Min.	3·0	0·4	2·0	37·5	5·50	5·5	6·800	350	25	60·0	3·0	2·0	37·0	9·0	
Max.	5·5	0·5	2·5	56·5	14·00	8·1	11·800	466	34	65·0	7·0	4·0	89·0	30·0	
15 weeks 4 Mean	4·1	0·4	2·5	39·7	9·55	8·3	9·700	474	31	61·5	5·2	2·0	56·0	23·7	
Min.	3·0	0·4	1·0	32·5	8·15	5·5	7·300	368	23	53·0	3·0	1·0	45·0	19·0	
Max.	5·0	0·45	3·5	43·5	11·00	8·7	13·500	572	40	66·0	9·0	3·0	78·0	28·0	
16 weeks 4 Mean	5·1	0·4	2·7	36·9	10·50	7·9	9·100	437	26	68·7	2·2	1·7	46·2	28·2	
Min.	3·5	0·4	2·5	33·5	9·30	7·5	7·900	300	19	56·0	1·0	1·0	43·0	27·0	
Max.	7·0	0·5	3·0	39·0	11·30	8·9	10·500	568	38	77·0	4·0	7·0	50·0	29·0	
17 weeks 4 Mean	4·1	0·4	2·0	41·1	11·75	7·5	8·900	388	19	68·0	6·5	6·7	56·5	28·0	
Min.	3·0	0·4	1·5	38·5	8·60	7·3	7·500	229	10	49·0	3·0	5·0	51·0	22·0	
Max.	6·0	0·4	2·5	47·5	15·00	7·8	12·200	578	34	78·0	9·0	8·0	65·0	32·0	
18 weeks 5 Mean	4·6	0·4	2·5	47·0	12·10	7·4	9·900	304	23	64·6	7·2	5·0	58·8	27·2	
Min.	3·5	0·35	2·0	34·0	9·80	6·2	9·000	212	17	54·0	3·0	2·0	50·0	24·0	
Max.	6·5	0·5	4·0	52·0	14·10	10·4	11·100	532	33	77·0	12·0	8·0	68·0	31·0	
19 weeks 4 Mean	6·0	0·35	2·25	42·6	13·05	9·9	11·300	292	23	65·7	5·7	5·0	45·5	30·2	
Min.	5·0	0·25	1·5	41·5	10·70	7·3	9·400	241	19	62·0	2·0	1·0	28·0	26·0	
Max.	6·5	0·5	3·0	45·0	15·00	14·7	12·000	382	33	70·0	9·0	10·0	57·0	33·0	
20 weeks 4 Mean	6·4	0·45	2·0	46·5	12·50	8·1	9·900	242	15	75·5	5·2	3·7	56·2	26·7	
Min.	4·5	0·45	1·0	45·0	11·60	6·1	9·000	224	11	70·0	2·0	1·0	38·0	24·0	
Max.	9·0	0·5	3·5	48·0	13·50	12·6	10·700	278	20	83·0	12·0	8·0	72·0	29·0	
21 weeks 5 Mean	6·1	0·35	2·1	42·8	12·50	8·5	10·300	348	24	65·4	6·0	4·4	49·4	28·0	
Min.	5·0	0·25	1·0	39·0	12·20	7·6	8·500	249	18	62·0	1·0	2·0	37·0	27·0	
Max.	7·0	0·5	3·5	46·0	12·70	11·2	13·000	524	35	71·0	12·0	10·0	57·0	31·0	

Age of Calves in Weeks	No. of Calves Bled		Coagulation Time (Minutes)	Fragility of Erythrocytes (% Saline)	Blood Sedimentation Rate (mm.)	Packed Cell Volume (mm.)	Hæmoglobin Content (G. per 100 cc.) of Blood	Erythrocyte Count (Millions per cmm.)	Total Leucocyte Count	Platelet Count (Thousands)	Neutrophils (per cent.)	Lymphocytes (per cent.)	Monocytes (per cent.)	Eosinophils (per cent.)	Mean Corpuscular Volume (c. microns)	Mean Corpuscular Hæmoglobin Concentration (per cent.)
22 weeks	7	Mean	6·6	0·45	2·1	43·1	13·20	8·3	9·200	323	22	68·0	5·0	5·0	53·7	30·1
		Min.	5·5	0·35	1·5	39·5	11·90	6·1	4·500	202	11	55·0	1·0	2·0	38·0	27·0
		Max.	8·0	0·5	3·0	47·0	14·45	11·3	12·100	458	31	75·0	12·0	14·0	72·0	35·0
23 weeks	5	Mean	7·2	0·45	1·7	43·7	12·20	7·0	9·100	329	24	67·4	4·8	4·2	64·4	27·8
		Min.	6·5	0·4	1·0	40·5	11·75	4·8	6·000	238	12	56·0	1·0	1·0	50·0	25·0
		Max.	8·5	0·5	3·0	49·5	12·50	8·0	12·200	538	29	81·0	8·0	8·0	91·0	30·0
24 weeks	5	Mean	6·9	0·45	2·4	45·4	12·20	6·1	9·500	352	21	68·2	5·4	5·6	76·0	27·4
		Min.	6·0	0·4	2·0	36·5	10·70	5·3	7·000	238	10	65·0	2·0	2·0	53·0	19·0
		Max.	9·0	0·5	3·0	54·5	14·40	8·0	12·400	478	31	72·0	12·0	11·0	102·0	39·0
25 weeks	5	Mean	6·6	0·45	2·5	39·6	12·10	6·6	10·300	435	23	68·8	4·0	4·2	60·2	30·8
		Min.	5·5	0·35	1·0	31·0	10·85	5·1	6·200	310	15	61·0	0·0	0·0	53·0	28·0
		Max.	8·5	0·5	4·0	45·0	13·80	8·1	13·700	504	39	74·0	10·0	9·0	82·0	35·0
26 weeks	5	Mean	7·6	0·45	2·5	40·7	13·62	8·1	7·900	374	22	68·6	5·4	4·2	53·4	30·8
		Min.	5·5	0·4	1·0	38·0	10·40	5·6	6·900	202	12	61·0	4·0	1·0	38·0	26·0
		Max.	11·0	0·5	3·0	44·0	14·50	10·5	10·300	460	31	74·0	9·0	12·0	78·0	38·0
27 weeks	6	Mean	6·3	0·5	3·1	38·2	11·50	8·6	10·300	333	21	63·2	5·2	10·0	52·8	30·3
		Min.	5·0	0·4	1·0	33·0	9·60	5·2	9·400	210	15	55·0	2·0	4·0	35·0	27·0
		Max.	7·5	0·5	5·0	46·5	13·25	11·1	12·700	457	27	78·0	11·0	15·0	79·0	34·0
28 weeks	6	Mean	7·3	0·45	2·3	37·1	10·70	7·1	9·800	252	20·5	64·0	6·6	8·5	54·1	29·0
		Min.	6·0	0·25	2·0	32·5	8·70	5·4	8·300	208	14·0	55·0	5·0	3·0	38·0	26·0
		Max.	8·5	0·5	3·0	42·5	12·20	10·2	12·900	390	26·0	78·0	8·0	12·0	80·0	34·0
29 weeks	5	Mean	6·6	0·5	1·9	36·5	10·30	7·9	9·800	446	18·0	66·7	7·7	7·5	45·0	28·8
		Min.	5·5	0·5	1·5	34·0	9·50	7·1	6·200	326	6·0	52·0	5·0	4·0	41·0	24·0
		Max.	7·5	0·5	3·0	39·0	11·90	8·6	12·500	542	24·0	82·0	12·0	12·0	49·0	33·0
30 weeks	4	Mean	5·9	0·5	2·5	35·6	10·60	6·9	9·900	421	25·0	62·2	5·0	8·0	51·0	30·2
		Min.	4·0	0·5	2·5	33·0	9·50	4·6	9·200	384	19·0	49·0	4·0	4·0	41·0	28·0
		Max.	7·5	0·5	3·0	38·0	11·70	9·1	10·500	452	30·0	70·0	8·0	13·0	63·0	32·0
31 weeks	5	Mean	6·6	0·5	3·0	36·7	11·80	6·4	10·400	338	19·0	69·6	3·6	6·6	57·2	32·2
		Min.	5·0	0·5	2·0	30·0	10·70	4·9	9·300	216	11·0	61·0	2·0	2·0	51·0	26·0

		Max.	7·5	0·5	3·0	38·0	11·70	9·1	10·500	452	30·0	70·0	3·0	13·0	63·0	32·0
31 weeks	5	Mean	6·6	0·5	3·0	36·7	11·80	6·4	10·400	338	19·0	69·6	3·6	6·6	57·2	32·2
		Min.	5·0	0·5	2·0	30·0	10·70	4·9	9·300	216	11·0	61·0	2·0	2·0	51·0	26·0
		Max.	7·5	0·5	5·0	45·0	12·90	7·2	12·000	498	25·0	82·0	6·0	11·0	68·0	39·0
32 weeks	4	Mean	5·7	0·45	2·7	37·1	9·90	7·3	8·800	286	30·0	62·5	2·7	4·7	52·0	26·5
		Min.	2·5	0·4	2·0	33·5	6·30	5·6	6·800	154	24·0	50·0	1·0	1·0	43·0	16·0
		Max.	8·0	0·5	3·0	40·0	11·45	8·4	9·700	391	39·0	69·0	4·0	9·0	59·0	32·0
33 weeks	4	Mean	5·5	0·45	4·5	32·1	10·20	6·1	11·000	313	27·0	67·0	2·5	4·7	55·5	31·5
		Min.	3·0	0·4	2·5	26·0	8·75	4·0	9·500	198	13·0	49·0	1·0	1·0	42·0	21·0
		Max.	8·5	0·5	6·5	37·0	12·80	8·8	15·000	370	36·0	85·0	6·0	9·0	69·0	36·0
34 weeks	4	Mean	5·5	0·45	4·9	32·5	11·30	5·7	10·700	295	26·0	68·0	3·0	3·2	58·7	34·7
		Min.	2·5	0·4	2·0	26·0	8·30	4·3	7·700	174	20·0	64·0	1·0	1·0	44·0	33·0
		Max.	7·5	0·5	7·0	39·0	14·75	7·2	13·300	414	30·0	75·0	4·0	6·0	71·0	37·0
35 weeks	4	Mean	5·1	0·45	4·1	35·1	9·65	7·3	10·400	269	26·0	67·0	2·0	5·0	49·7	27·7
		Min.	3·0	0·4	2·0	28·0	4·60	4·8	8·000	180	19·0	60·0	1·0	1·0	35·0	13·0
		Max.	7·0	0·5	6·5	45·0	14·45	8·6	12·300	310	34·0	77·0	3·0	12·0	69·0	34·0
36 weeks	4	Mean	5·4	0·45	4·1	35·2	10·90	7·3	11·300	372	31·0	62·0	2·5	4·7	49·0	31·5
		Min.	3·0	0·4	3·0	25·0	8·15	4·5	7·600	100	26·0	54·0	1·0	2·0	43·0	30·0
		Max.	7·5	0·5	7·0	42·0	12·80	8·7	14·500	646	37·0	69·0	4·0	10·0	55·0	33·0
37 weeks	4	Mean	8·6	0·5	3·9	36·7	10·75	7·4	9·700	346	25·0	71·0	2·2	1·7	54·0	29·7
		Min.	6·0	0·5	2·5	24·0	8·00	5·5	9·200	294	21·0	64·0	0·0	1·0	48·0	27·0
		Max.	10·0	0·5	7·0	43·0	12·35	8·6	10·600	448	30·0	76·0	4·0	2·0	57·0	34·0
38 weeks	4	Mean	6·3	0·5	4·0	35·3	11·10	6·3	9·600	456	25·0	70·0	1·7	3·0	55·7	31·7
		Min.	6·0	0·5	3·0	28·0	8·75	5·6	8·800	350	14·0	62·0	1·0	1·0	42·0	30·0
		Max.	7·0	0·5	6·0	41·0	12·50	6·8	10·600	562	35·0	80·0	2·0	4·0	62·0	33·0
39 weeks	4	Mean	6·0	0·5	5·4	29·1	10·60	5·6	9·800	291	20·0	73·0	3·2	3·7	51·5	35·7
		Min.	3·0	0·5	4·0	25·0	8·75	4·7	8·600	272	15·0	71·0	1·0	1·0	42·0	35·0
		Max.	10·0	0·5	6·0	31·0	11·70	6·0	11·100	358	23·0	76·0	5·0	10·0	62·0	37·0
40 weeks	4	Mean	6·6	0·5	5·0	34·2	9·40	6·9	10·200	383	23·0	70·0	4·0	3·2	50·0	27·0
		Min.	4·0	0·5	3·0	29·0	8·30	5·8	8·000	270	15·0	61·0	1·0	1·0	39·0	25·0
		Max.	8·5	0·5	7·0	41·0	11·45	7·4	13·500	590	35·0	83·0	11·0	7·0	57·0	29·0
41 weeks	4	Mean	6·9	0·5	4·9	31·6	10·30	5·1	10·300	303	28·0	67·2	2·5	2·2	62·0	32·7
		Min.	3·5	0·5	3·5	28·0	9·95	4·0	8·900	192	18·0	57·0	1·0	1·0	55·0	27·0
		Max.	8·5	0·5	6·5	39·0	10·70	6·8	11·500	342	34·0	80·0	5·0	4·0	77·0	39·0
42 weeks	4	Mean	5·2	0·45	4·2	32·7	11·30	6·2	8·700	302	29·0	58·2	3·2	9·2	53·2	33·0
		Min.	4·0	0·4	3·0	29·0	9·80	5·2	6·700	254	11·0	48·0	2·0	2·0	44·0	28·0
		Max.	6·5	0·5	6·5	35·0	13·00	7·7	9·700	352	44·0	75·0	6·0	12·0	68·0	39·0

Age of Calves in Weeks	No. of Calves Bled		Coagulation Time (Minutes)	Fragility of Erythrocytes (% Saline)	Blood Sedimentation Rate (mm.)	Packed Cell Volume (mm.)	Hæmoglobin Content (G. per 100 cc.) of Blood	Erythrocyte Count (Millions per cmm.)	Total Leucocyte Count	Platelet Count (Thousands)	Neutrophils (per cent.)	Lymphocytes (per cent.)	Monocytes (per cent.)	Eosinophils (per cent.)	Mean Corpuscular Volume (c. microns)	Mean Corpuscular Hæmoglobin Concentration (per cent.)
43 weeks	4	Mean	4·0	0·45	4·4	34·9	11·70	6·4	9·600	346	22·0	64·7	5·7	7·2	52·7	33·0
		Min.	2·0	0·45	1·5	32·0	10·70	5·5	6·800	170	16·0	57·0	3·0	3·0	47·0	29·0
		Max.	5·5	0·5	4·5	37·5	13·80	7·7	12·200	480	27·0	71·0	8·0	10·0	58·0	40·0
44 weeks	4	Mean	4·2	0·5	4·9	29·7	10·20	6·3	9·700	267	21·0	69·5	3·7	5·7	62·7	36·0
		Min.	2·5	0·5	3·0	20·0	9·50	4·6	8·200	124	16·0	61·0	2·0	3·0	48·0	28·0
		Max.	5·5	0·5	7·0	34·5	11·10	7·4	10·500	370	26·0	78·0	6·0	10·0	83·0	55·0
45 weeks	4	Mean	4·4	0·45	4·0	29·5	11·70	5·6	9·100	365	30·0	60·5	4·7	4·2	67·7	43·7
		Min.	3·0	0·4	3·0	18·0	10·25	3·1	8·000	262	19·0	51·0	2·0	3·0	50·0	30·0
		Max.	6·0	0·5	5·0	35·0	13·20	7·6	10·500	504	36·0	72·0	10·0	6·0	112·0	73·0
46 weeks	4	Mean	5·4	0·45	2·9	30·9	11·50	5·6	8·800	302	26·0	63·7	4·5	6·2	57·7	37·7
		Min.	3·0	0·45	1·0	27·5	10·80	3·5	7·700	218	19·0	49·0	2·0	2·0	45·0	32·0
		Max.	9·0	0·5	4·0	34·5	12·70	7·7	10·600	370	34·0	72·0	7·0	11·0	80·0	45·0
47 weeks	4	Mean	5·5	0·5	4·0	32·3	10·00	7·1	9·200	270	26·0	66·7	3·0	4·5	49·7	30·7
		Min.	2·5	0·5	3·5	29·5	8·30	4·3	8·200	198	24·0	61·0	1·0	2·0	30·0	27·0
		Max.	7·5	0·5	4·5	36·5	11·70	12·2	10·200	368	28·0	73·0	4·0	11·0	68·0	39·0
48 weeks	4	Mean	5·7	0·5	4·6	36·2	10·60	5·4	10·100	352	31·0	63·2	3·2	2·0	68·0	29·5
		Min.	5·0	0·5	4·0	33·0	9·35	5·0	9·000	210	27·0	55·0	3·0	1·0	59·0	25·0
		Max.	6·5	0·5	5·0	43·5	12·20	5·7	10·500	424	41·0	67·0	4·0	3·0	88·0	35·0
49 weeks	4	Mean	6·4	0·5	3·0	40·9	12·60	6·2	10·100	315	28·0	65·0	2·7	2·0	64·5	31·2
		Min.	4·5	0·5	2·5	37·0	11·45	5·8	8·300	268	18·0	50·0	2·0	2·0	56·0	27·0
		Max.	8·0	0·5	3·5	44·0	13·85	7·5	12·700	342	46·0	72·0	5·0	2·0	70·0	36·0
50 weeks	4	Mean	6·4	0·5	3·0	40·2	12·20	6·5	9·900	355	25·0	70·5	2·0	2·2	64·5	30·5
		Min.	6·0	0·5	2·0	34·0	10·40	5·8	8·900	328	20·0	60·0	1·0	1·0	57·0	28·0
		Max.	7·0	0·5	5·0	44·0	14·15	7·2	12·200	422	36·0	76·0	3·0	4·0	73·0	34·0
51 weeks	4	Mean	5·9	0·45	4·2	33·7	10·85	5·9	9·000	323	26·0	68·2	3·2	2·7	58·7	32·5
		Min.	4·5	0·45	3·5	31·5	9·20	4·1	8·800	222	23·0	66·0	2·0	2·0	50·0	30·0
		Max.	8·0	0·5	5·0	38·0	12·50	7·0	9·200	402	30·0	71·0	4·0	5·0	81·0	35·0
52 weeks	4	Mean	5·4	0·45	4·5	36·9	9·05	7·5	10·900	266	28·0	67·0	2·2	3·0	50·7	25·7
		Min.	3·0	0·4	3·0	28·5	7·20	6·5	8·200	214	20·0	62·0	2·0	2·0	44·0	14·0
		Max.	6·5	0·5	6·0	50·5	10·70	10·0	14·500	314	34·0	72·0	3·0	6·0	59·0	31·0

OBSERVATIONS ON THE TRANSMISSIBILITY AND PATHOGENESIS OF MONILIASIS IN TURKEY POULTS

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EARLIER work on the transmissibility of this disease has already been described briefly (Blaxland, 1951). It seemed reasonable to deduce from those experiments: (1) that inoculation of poults with pure culture of *Candida albicans* caused infection without lesions or symptoms; (2) that the infection was transmitted to other poults by contact; and (3) that poults from a field outbreak of moniliasis transmitted the clinical disease to healthy poults by contact under laboratory conditions, although through one passage only. Two further experiments have since been carried out in an attempt to confirm the first two deductions, to elucidate the aetiology of the disease and to investigate its pathogenesis.

In the earlier work already quoted, *C. albicans* was isolated from the crops of 27 per cent of 329 turkeys and 51 per cent of 146 fowls sent to the laboratory for routine autopsy. In view of this evidence of the widespread distribution of the organism, it was also decided to carry out a survey involving the examination of crops and other organs of clinically healthy poults obtained from turkey farms in different parts of the country.

Experiment I.—Inoculation with a Pure Culture of C. albicans

The strain of *C. albicans* used had been isolated from a baby chick with clinical moniliasis. 1 ml. of a saline suspension inoculated intravenously killed

TABLE I

Experiment I. Group 1. Oral administration of C. albicans culture

		Mycological examination					Histological examination
	Poult	Crop	Liver	Spleen	Kidneys	Intestine	Crop
1.	Infected	u.y.	—	—	—	C.a.	Heavy, surface, spore infection; a little hyphal proliferation.
2.	„	C.a.	—	—	—	C.a. & u.y.	Focally variable, surface, spore infection with hyphal proliferation.
3.	„	C.a.	—	u.y.	—	C.a.	Light, surface, spore infection; a little hyphal proliferation.
4.	„	C.a.	—	—	—	C.a. & u.y.	Very light, surface, spore infection; a little hyphal proliferation.
5.	„	C.a.	—	—	—	C.a. & u.y.	Quite heavy, spore infection; only a few hyphæ; slight penetration into the epithelium—very early moniliasis.
6.	„	C.a.	—	—	u.y.	C.a.	Heavy, surface, spore infection.
7.	Contact	C.a.	—	—	u.y.	u.y.	Light, surface, spore infection; a little hyphal proliferation.
8.	„	C.a.	—	u.y.	u.y.	C.a. & u.y.	Light, surface, spore infection; no proliferation.
9.	„	C.a.	—	u.y.	C.a.	u.y.	One spore seen in each section.
10.	„	C.a.	—	—	u.y.	C.a.	Heavy, surface, spore infection; no proliferation.

C.a. = *Candida albicans* isolated; u.y. = untyped yeast isolated.

TABLE II

Experiment I. Group 2. Intraperitoneal inoculation of C. albicans culture

	Poult	Mycological examination Crop	Liver	Spleen	Kidneys	Intestine	Histological examination Crop
1.	Infected	C.a.	—	—	—	u.y.	Quite heavy surface infection with spores and hyphæ.
2.	„	u.y.	—	—	—	—	Variable, surface, spore infection; very few hyphæ.
3.	„	C.a.	u.y.	—	C.a.	C.a.	Focal infection of variable intensity.
4.	„	C.a.	—	—	—	C.a.	Light to moderate, surface, spore infection.
5.	„	C.a. & u.y.	—	—	—	C.a.	Very light, surface, spore infection.
6.	„	C.a.	—	—	C.a.	C.a.	Very light, surface, spore infection; one focus of typical epithelial changes and marked hyphal proliferation.
7.	Contact	C.a.	u.y.	—	—	u.y.	Quite heavy spore infection; hyphal proliferation.
8.	„	C.a.	—	—	u.y.	—	Light, surface, spore infection.
9.	„	C.a.	—	C.a.	C.a.	C.a.	Moderate, surface, spore infection.
10.	„	C.a. & u.y.	C.a.	—	—	C.a.	Moderately severe moniliasis with hyphæ penetrating into the epithelium.

a rabbit in two days, causing typical lesions. The culture recovered from this rabbit was used for the experiment as a saline suspension with a density equal to No. 5 Brown's scale. By using a culture, it was hoped to ascertain the rôle of the yeast alone as a pathogen and to study the possibility that the yeast possessed an endotoxin, as suggested by the work of Salvin (1952) and Savlin *et al.* (1952).

TABLE III

Experiment I. Group 3. Subcutaneous inoculation of C. albicans culture

	Poult	Mycological examination Crop	Liver	Spleen	Kidneys	Intestine	Histological examination Crop
1.	Infected	C.a.	—	—	—	C.a.	Moderately heavy infection with hyphal proliferation; essentially superficial.
2.	„	u.y.	C.a.	—	—	u.y.	Moderate, focal, surface spore infection.
3.	„	C.a.	C.a.	—	C.a.	u.y.	Moderate, focal moniliasis.
4.	„	C.a. & u.y.	—	C.a.	C.a.	u.y.	Light, surface, spore infection; a few hyphæ.
5.	„	—	—	—	—	C.a. & u.y.	Very light, focal, surface infection.
6.	„	C.a.	—	u.y.	u.y.	u.y.	Very light, focal, surface infection.
7.	Contact	—	—	—	—	—	Variable, light, surface, spore infection.
8.	„	C.a. & u.y.	—	C.a.	u.y.	C.a. & u.y.	Moderate, focal monliasis.
9.	„	C.a. & u.y.	C.a.	—	—	u.y.	Light but definite, surface infection; two foci of invading hyphæ in one section.
10.	„	C.a.	—	—	—	u.y.	Light to moderate, surface, spore infection.
11.	„	C.a.	—	u.y.	u.y.	u.y.	Negative.

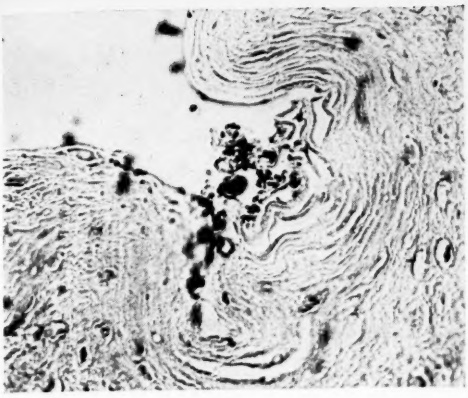

Fig. 1
Very light, surface, spore infection. x 1216. Gram-Claudius.

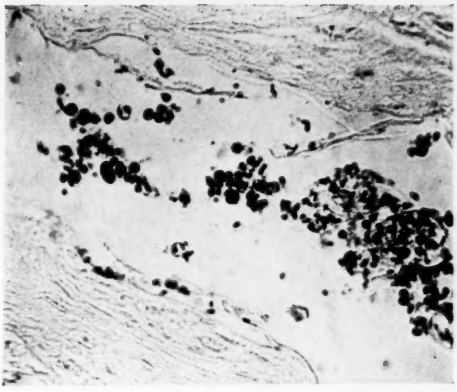

Fig. 2
Heavy, surface, spore infection. The deep invagination of the mucosa is due to wrinkling after death and fixation. x 1216. Gram-Claudius.

Fig. 3
Quite heavy, surface, spore infection with hyphal proliferation. There is no penetration of the epithelium. x 1216 Gram-Claudius.

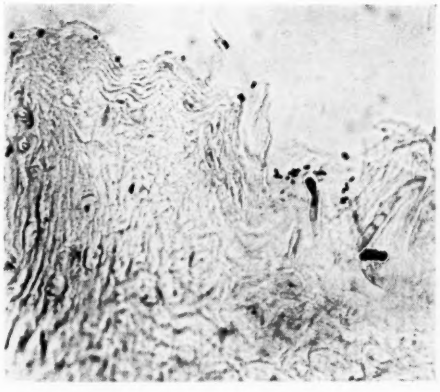

Fig. 4
Only a few hyphæ, but slight penetration into the epithelium—very early moniliasis. x 1216. Gram-Claudius.

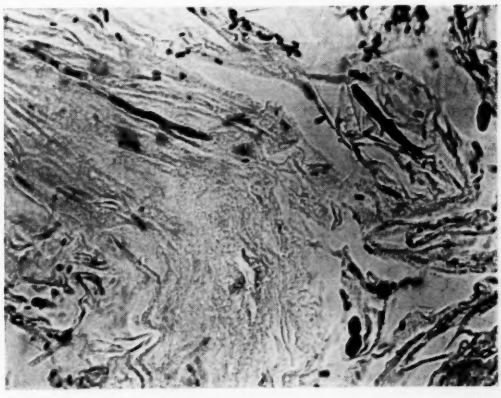

Fig. 5
Hyphæ penetrating into the epithelium—moderately severe moniliasis. x 1216. Gram-Claudius.

(*Article by Blaxland and Markson, page 139*)

XUM

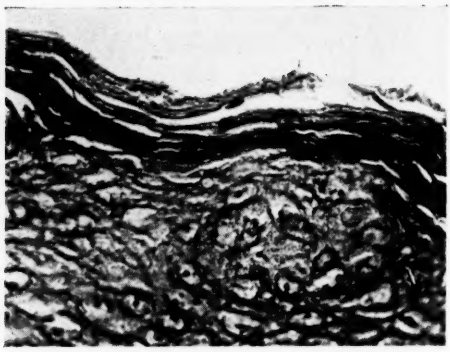

Fig. 6
Normal crop epithelium. x 1216. Hæmatoxylin and eosin.

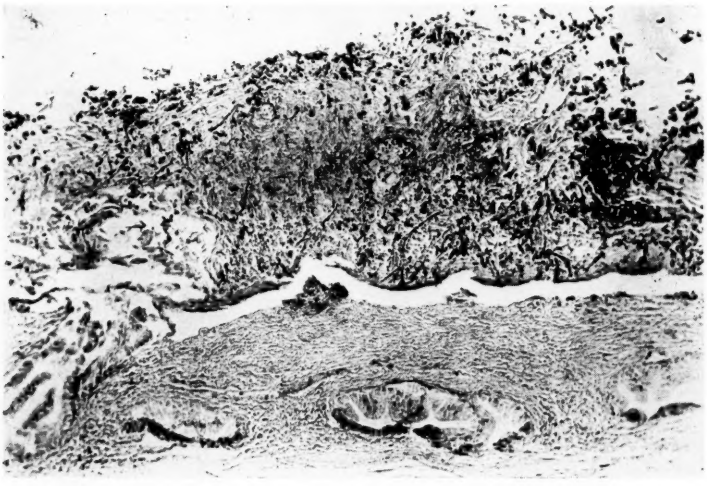

Fig. 7
Naturally-occurring, clinical case of moniliasis. x 216. Gram-Claudius.

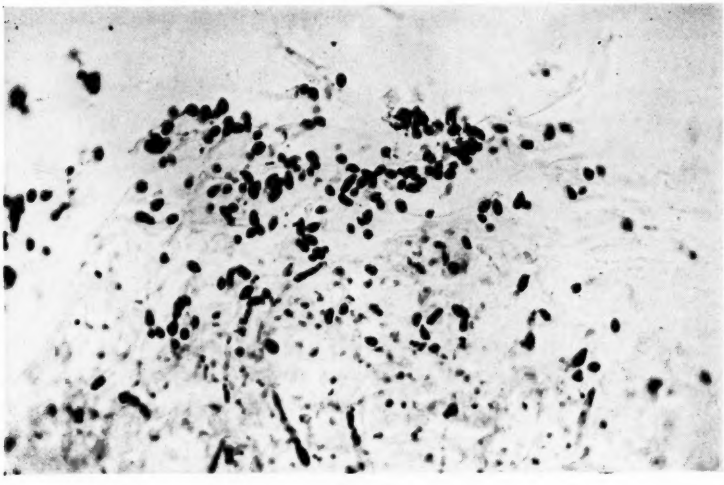

Fig. 8
The same as Fig. 7. x 1216.

(*Article by Blaxland and Markson, page 139*)

XUM

Thirty-nine, two-week-old, healthy poults were divided into four groups and placed under electric hovers at approximately 32°C. in a heated brooder house. The poults were fed a standard chick mash moistened with fresh milk.

Group 1. Six poults were given 1 ml. of culture orally once a day for six consecutive days. Four uninoculated poults were put into the same pen.

Group 2. Six poults were given a single intraperitoneal injection of 0.5 ml. of culture. Four uninoculated poults were put into the same pen.

Group 3. Six poults were given a single subcutaneous injection of 0.5 ml. of culture. Four uninoculated poults were put into the same pen.

TABLE IV

Experiment I. Group 4. Controls

Poult	Mycological examination					Histological examination
	Crop	Liver	Spleen	Kidneys	Intestine	Crop
1.	u.y.	—	u.y.	u.y.	u.y.	Moderate, surface, spore infection.
2.	—	u.y.	—	—	u.y.	Negative.
3.	u.y.	u.y.	—	—	—	Very light, surface, spore infection.
4.	u.y.	—	—	u.y.	u.y.	Negative.
5.	u.y.	C.a.	—	—	u.y.	Very light, surface, spore infection.
6.	u.y.	—	—	—	u.y.	Negative.
7.	u.y.	—	—	—	—	Negative.
8.	u.y.	—	—	—	—	Very light, surface, spore infection.

Group 4. Nine poults were kept in a separate pen in the same brooder house to serve as controls. One subsequently escaped and joined Group 3 with which it was left.

There was no mortality in any of the groups, neither were any symptoms of disease observed. Growth and progress were normal. After four weeks, the poults were killed and examined as described later.

Experiment II.—Inoculation with a Suspension of Crop Scrapings from Clinical Cases of Moniliasis

A crude saline suspension of crop scrapings was prepared from 20 poults collected from a field outbreak. The carcases were brought to the Laboratory where the crops were removed and stored unopened at —20° C. They were thawed when required and the viability of the material checked by isolation of *C. albicans* from the crop mucosa and from the saline suspension. A suspension, fine enough to pass through a medium bore needle, was prepared by forcing material through a syringe. This was used for the intraperitoneal inoculations, while the crude suspension, containing large flakes of epithelial debris and mycelia, was used for oral administration. By using this material, it was intended to explore the possibility that field outbreaks of moniliasis might be the result of an association between *C. albicans* and some bacterial or viral agent.

Thirty, two-week-old, healthy turkey poults were divided into three equal groups and managed under conditions similar to those of the first experiment.

Group 1. Six poults were given 1 ml. of crude suspension orally, once a day for six consecutive days. Four uninoculated poults were put into the same pen.

Group 2. Six poults were inoculated intraperitoneally with 1 ml. of fine suspension. Four uninoculated poults were put into the same pen.

Group 3. Ten poults were kept in a separate pen in the same brooder house to act as controls.

TABLE V

Experiment II. Group 1. Oral administration of crop scrapings

	Poult	Mycological examination					Histological examination
		Crop	Liver	Spleen	Kidneys	Intestine	Crop
1.	Infected	C.a.	—	—	u.y.	C.a.	Light, surface, spore infection.
2.	„	—	—	u.y.	—	u.y.	Very light, surface, spore infection.
3.	„	—	u.y.	—	—	—	„ „ „ „ „
4.	„	C.a.	—	u.y.	u.y.	u.y.	„ „ „ „ „
5.	„	u.y.	—	—	—	—	„ „ „ „ „
6.	„	C.a. & u.y.	—	—	—	u.y.	„ „ „ „ „
7.	Contact	u.y.	—	—	u.y.	u.y.	„ „ „ „ „
8.	„	C.a.	—	—	—	C.a.	„ „ „ „ „
9.	„	—	u.y.	—	—	C.a.	Light, surface, spore infection.
10.	„	—	—	—	—	—	Very light, surface, spore infection.

There was no mortality in any of the groups, neither were any symptoms of disease observed. Growth and progress were normal. After seven weeks, the poults were killed and examined.

Technique of Examination

Routine autopsies were carried out on all the poults. The crops were examined for gross lesions of moniliasis and intestinal smears for coccidia. The crops and other tissues were fixed in 10 per cent formol-saline and paraffin blocks prepared. Sections were stained by the Gram-Claudius technique to demonstrate the fungus and by Ehrlich's hæmatoxylin and eosin.

The yeasts isolated were examined and typed by the methods already reported (Blaxland and Fincham, 1950; Blaxland, 1951). No attempt was made to identify other yeasts once it had been established that they were not members of the *Candida* group, as judged by their failure to produce mycelia on maize meal agar (Benham, 1951). Many appeared to be of the cryptococcus type, but there is no evidence to suggest that this organism is a poultry pathogen. Other cultures were made to eliminate the possibility of bacterial infection.

Results

All the crops were grossly normal. No pathological changes or fungi were seen in sections of any of the organs examined, except those of the crops. The results of the examination of the poults in the two experiments are detailed in the accompanying tables.

Interpretation of Histological Findings

It appeared that the first step in the disease process was the deposition of spores on the surface of the crop epithelium. This was sometimes followed by

the production of hyphæ. So long as the hyphæ remained on the surface, no tissue reaction was seen and a few could even grow into the epithelium without apparent reaction. Eventually, however, if penetration increased, surface squames piled up as debris, while epithelial proliferation and keratosis increased below the site of reaction; this we have interpreted as moniliasis. The poults in these experiments showed no further progress to clinical disease. Although the changes in their crops were not visible macroscopically, microscopical examination revealed that in some individuals infection had given way to the tissue reaction of disease.

TABLE VI

Experiment II. Group 2. Intraperitoneal administration of crop scrapings

	Mycological examination					Histological examination
Poult	Crop	Liver	Spleen	Kidneys	Intestine	Crop
1. Infected	u.y.	—	—	u.y.	—	Light, surface, spore infection.
2. „	C.a.	u.y.	—	u.y.	C.a.	Very light, surface, spore infection.
3. „	u.y.	—	—	—	—	„ „ „ „ „
4. „	—	—	—	—	—	Hyphæ seen focally in surface layers of epithelium.
5. „	u.y.	—	—	—	C.a.	Light, surface, spore infection.
6. „	u.y.	—	C.a.	—	—	A few hyphæ on the epithelial surface.
7. Contact	C.a.	—	—	—	C.a.	Light, surface, spore infection.
8. „	—	u.y.	—	—	C.a.	„ „ „ „
9. „	u.y.	—	—	—	—	„ „ „ „
10. „	u.y.	—	u.y.	—	—	Moderate, surface, spore infection.

This interpretation of the histological picture was complicated by the fact that Gram-positive bodies, indistinguishable in appearance from the spores of *C. albicans,* were present on the epithelial surface of the crops of four out of the eight control poults in the first experiment and of all the controls in the second; yet the yeasts isolated in culture from these poults were not *C. albicans.* It seems probable that these bodies were the spores of other, free-living, yeasts.

Survey of Healthy Turkey Poults

During the period March-October, 1951, poults from four to six weeks old were taken at random from different brooders on five farms in five different counties. They were sent to the Laboratory alive and killed immediately they arrived, thus ensuring that any infection present in the crops must have been acquired on the farm. The poults were examined as already described and the results are given as follows:—

Farm 1. Four or five poults examined on five consecutive weeks.

Farm 2. Five poults examined on five consecutive weeks.

Farm 3. Five poults examined on two consecutive weeks.

A total of 57 poults was examined from these three farms and *C. albicans* was not isolated from any of them, neither was there any gross or microscopic evidence of moniliasis or of mycotic infection.

TABLE VII

Experiment II. Group 3. Controls

Mycological examination	Histological examination
All cultures were negative for *C. albicans*. Only untyped yeasts were isolated.	All the crop sections showed a light to very light, surface infection with Gram-positive yeast-like spores.

Farm 4. Five poults examined on two consecutive weeks. There was no evidence in these ten poults of moniliasis or of mycotic infection, except that *C. albicans* was isolated from the crop of one.

Farm 5. A total of 25 poults was examined on five consecutive weeks:—

1st week. There were gross lesions of moniliasis in the crop of one bird and *C. albicans* was isolated from all five. The poult with crop lesions was in poor condition whilst the other four were healthy.

2nd week. All five poults were in excellent condition, although four had extensive crop mycosis typical of moniliasis. *C. albicans* was isolated from the crops of all five birds and from the intestines of three.

3rd week. All five poults were in excellent condition. There were no lesions in the crops, but *C. albicans* was isolated from them all and from the intestines of two of them.

4th and 5th weeks. All ten poults were in excellent condition. There were no lesions in the crops, although *C. albicans* was isolated from one of them in the fifth week.

The owner of the stock obtained from Farm 5 reported a normal rearing season with no abnormal mortality in the brooders from which the infected poults had been taken. Labour difficulties had been experienced on this farm during the season with the result that general management and hygiene had been below the standard usually maintained.

Discussion

The results of the experiments described in this paper confirm the conclusions already reached in connection with the transmissibility of moniliasis (Blaxland, 1951). In the first experiment, infection was established in poults by administration of *C. albicans* culture intraperitoneally as well as orally. Although the yeast was recovered from other organs, histological examination suggested that the crop was the predilection site, even after parenteral inoculation. Poults infected by all three routes infected other poults with which they were in contact. But *C. albicans* culture alone was insufficient to cause either clinical moniliasis or gross crop lesions; infection consisted of something more than the mere presence of the organism in the tissues. Although the yeast was recovered in culture from liver, kidneys, spleen and intestines, it could not be demonstrated there in sections. Only on the epithelial surface of the crop were spores seen; their presence there could not always have been due to mechanical factors, for in some sections hyphæ had developed, sometimes penetrating into the epithelium with production of

squamous debris. This last change we have interpreted as histological evidence of moniliasis, but in none of the experimental material did the pathological process go beyond this stage to gross or clinical evidence of the disease. There was nothing in the results to suggest the production of a toxin by this organism.

The results of the second experiment appear to disprove the possible association of other organisms, such as bacteria or viruses, with *C. albicans* as factors of importance in the ætiology of the disease.

Field investigations have shown that moniliasis is often associated with bad flock hygiene and inadequate nutrition. As already suggested in earlier papers, it would seem that these are the factors which convert infection to disease. The examination of the crops of diseased turkeys and fowls already reported, and the results of the survey described in this paper, suggest that *C. albicans* may be a common saprophyte or commensal in some flocks. It may be that the crop lesions are a secondary feature of some other disease; on the other hand, we do not know of any other disease of turkeys at all comparable to moniliasis but lacking the crop mycosis.

Summary

Two experiments and a field survey have been carried out in an attempt to elucidate the aetiology and pathogenesis of moniliasis in turkey poults. Enteral and parenteral administration of *C. albicans* culture produced infection in most of the inoculated and in-contact poults and sub-clinical moniliasis in a few of them. Administration of a suspension of crop scrapings from field cases of the disease produced similar results. There was no evidence of the presence of an endotoxin in the yeast. None of the birds in these experiments developed symptoms of moniliasis. The field survey demonstrated that *C. albicans* may be present in birds as a commensal and may even cause gross lesions in the crop, without any sign of clinical disease.

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A REVIEW OF KNOWLEDGE AVAILABLE CONCERNING DIGESTION IN DOMESTIC HERBIVORA

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PART I

THE basic difference between herbivorous and omniverous or carnivorous animals lies in the ability of herbivores to digest cellulose and related substances. Since mammals do not secrete cellulases, they depend on the utilization of the products of microbial activity. This has made it necessary to modify the digestive tract to provide a suitable environment for microbial fermentation. The usual adaptation has involved the enlargement of part of the tract to form a fermentation chamber. Most commonly the parts to undergo this modification have been the cæcum and colon. However, some species have in addition an enlarged part of the stomach. A good example of the first type of development is shown in the Equidæ and of the last in the Ruminant (Table I).

In their review of Ruminant Digestion, Elsden and Phillipson (1948) state that ruminants are anatomically better adapted to the herbivorous mode of life because they subject their ingesta to two fermentations; one before and the other following the usual mammalian digestive processes. Whether such a double fermentation is advantageous is open to question since ruminants ferment indiscriminately in the reticulo-rumen water-soluble carbohydrates (McAnally and Phillipson, 1942) as well as cellulose; they also deaminate amino-acids (Shazly, 1952*a*) producing ammonia, CO_2 and volatile fatty acid. Whereas the horse, for example, absorbs water soluble carbohydrates such as glucose directly from the small intestine (Alexander, 1954). Moreover, Bonnazzi (1951) found the horse digested more protein than either the cow or pig, probably because of the digestion of proteins in the small intestine without subjection to fermentation. However, both ruminant and monogastric herbivora under natural conditions have a similar diet and depend on the products of fermentation for much of their absorbable nutriments. Since the substrate for fermentation must differ in these types of herbivora, in the ruminant all digesta being liable to fermentation in the rumen whereas in the non-ruminant some parts of the diet are absorbed and the residue fermented, a study of digestion in two such species would probably help the understanding of the fundamental mechanisms of herbivorous digestion. The horse and domestic ruminant provide good examples of colon fermenting and stomach fermenting herbivores, respectively. Moreover, these species are very liable to diseases of digestion and are therefore of particular interest to veterinarians. The purpose of this review is to compare as far as possible digestion in the horse and ruminant and, in particular, to indicate the absence of information.

TABLE I

	Relative capacity of the parts of the digestive tract (per cent)			Ratio of capacity of total digestive tract (Litres)/ body-weight (kg.)
	Stomach	Small Intestine	Large Intestine	
Cat	70	15	15	16
Pig	30	33	37	25
Horse	9	30	61	33
Ox	71	19	10	50

Calculated by G. A. Levvy from data of Colin, G. (1886). *Trait. Physiol. Comparée.*

Mechanical Factors

The motor activities of the alimentary tract are fundamental to the digestive processes, serving to mix the digesta with the digestive secretions, to expose this mixture to the epithelium of the tract and to propel the residue along the bowel.

The movements of the reticulo-rumen have attracted the most interest and present many special features. They show a basic sequence of events which is subject to considerable variation and has been carefully analysed by Phillipson (1939). The reticulum shows a regular double contraction occurring about once each minute; this contraction forces the liquid digesta into the rumen. The reticulum then relaxes and fills with digesta from the rumen. The contractions of the rumen are slower and less forceful than those of the reticulum, the rumen contracting once or twice for each double reticulum contraction; the dorsal and ventral sacs of the rumen usually contracting alternately. This has been confirmed recently by Brunard and Dussardier (1953*a*). These authors have also directed attention to the vestibule of the rumen which appears to be a specialised part of this organ. The vestibule, prepyloric part of the abomasum and the reticulum are the only parts of the ruminant stomach to show spontaneous motility in freshly killed animals.

Stigler (1931, 1933) who has contributed to the study of rumination over the past twenty years has recently (1949) described a working model to illustrate the rumination mechanisation. This would probably be of value in teaching institutes.

Wise, Link, Thompson and Caldwell (1946) rumenectomised calves and found them to suffer no ill-effects other than a tendency to bloat and unthriftyness which was alleviated by the administration of rumen juice. The rumen tended to regenerate. Piana (1952) has made observations on rumenectomised sheep He found digesta to pass much more quickly along the alimentary tract than it did in normal sheep. It has long been known that the rumen developed in size as the young ruminant changed from a diet of milk to a normal herbivorous diet. Additional evidence of the effect of diet on rumen development has been provided by Blaxter, Brown and Macdonald (1952), who found that calves fed roughage had an increased capacity of their fore-stomachs, their large bowel was unchanged in capacity. An analogous change occurs in the horse (Alexander and Benzie, 1951). In weaned foals the cæcum and ventral colon

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occupied a much greater proportion of the abdominal cavity than in suckling foals. This development is presumably to provide the fermentation chamber necessary for the microbial digestion of the herbivorous diet.

The embryology of the bovine stomach has been studied by Becker, Arnold and Marshall (1951). These authors found the rumen to be the largest chamber of the stomach in early fœtal life, whilst at term the abomasum accounted for half the total weight of all parts of the stomach. Differentiation of the honeycomb occurred between 72 and 100 days. Duncan and Phillipson (1951) studied the motor activity of the stomach in fœtal sheep. They found the non-functional period to end after 50-60 days of gestation, but sustained activity was not seen until the 70th day; fœtal swallowing began soon after this time.

Some of the factors influencing the movements of the bovine stomach have been studied by Balch (1952). He found the reticulum contractions were quickest when the animal was eating and slowest during rumination. Omasal activity has been investigated by Balch, Kelly and Hein (1951) who concluded that digesta passed continuously from reticulum to omasum probably with each reticular contraction. The records shown by this group of investigators resemble the earlier records such as those of Schalk and Amadon (1928) who found continuous activity in the omasum consisting of slow powerful contractions. Brunard and Dussardier (1953*b*) have published tracings showing a relationship between reticulum contractions and the contractions of the omasum. They distinguished two types of omasal contractions The abomasal contractions described in this same paper are remarkably similar both in form and frequency to the contractions of the horse stomach (Alexander, 1951*a*).

Phillipson (1952) has studied the flow of digesta from the duodenum and found that about 300-450 ml. passed from the abomasum each hour. Distension of the duodenum decreased abomasal emptying as did the re-introduction of abomasal contents into the duodenum. More digesta left the abomasum after feeding cereal offals and meals than after feeding hay. There appeared to be no correlation between reticulum motility and abomasal emptying. Singleton (1951) has described abomasal-duodenal inhibitory reflexes in the goat similar to those of the dog; olive oil in the duodenum consistently produced abomasal inhibition whereas protein breakdown products only inhibited contractions on half the occasions tried.

The movements of the horse's stomach have received very little attention since the early studies of Colin (1886) who experimented on the stomachs of freshly killed horses. Colin found that when the pylorus was ligatured and intragastric pressure increased, the stomach ruptured before any contents escaped through the cardiac sphincter. The rupturing of the equine stomach has been studied in greater detail by Neumann-Kleinparl and Schultzler (1940). They found that rupturing took place parallel to the greater curvature and the pressure required was between 55 and 69 gm./sq. cm. The normal intra-gastric pressure was 10 gm./sq. cm. and in tympany it rose to 50 gm./sq. cm. Schalk and Amadon (1928) recorded intra-gastric pressures in the living horse, and found that powerful contractions occurred during feeding; these contractions did not

recur until 5 hours after feed. Schalk and Amadon termed these latter contractions " hunger contractions." However, it is very doubtful whether true hunger contractions occur in the horse (Alexander, 1951*a*). Observations on gastric contractions in the horse have been published recently by Brunard and Dussardier (1952*a*). The observations were made on animals anæsthetised with chloralose and the records obtained from a balloon passed into the stomach through an opening in the œsophagus. These experimental conditions may account for the difference in frequency of the stomach contractions recorded by Brunard and Dussardier (1952*a*) and those described by Alexander (1951*a*). The latter author found that only when the tube in the œsophagus was less than 6.5 mm. diam. was it possible to obtain a record of normal gastric movements.

The functions of the ileum have received little attention although the importance of this part of the digestive tract in ruminants is shown by the experiment of Besselaar and Quin (1935). These workers extirpated the lower half of the ileum in sheep and found that death took place within 12 months and was preceded by cachexia and diarrhœa; exclusion of the cæcum and upper colon had a similar effect. There was also a disturbance of water metabolism.

The paucity of information on the functions of the intestine of the horse has been due in the past to the difficulty of preparing permanent fistulæ into the various parts of the alimentary tract. However, it is now possible to make fistulæ into both small and large intestines (Alexander, 1951*b*, 1952). From in vitro and in vivo studies of the horse ileum it appears that any diminution in the oxygen supply to this organ, is accompanied by an inhibition of movement, (Alexander, 1949, 1950, 1952). It would be interesting to know whether the ruminant ileum is similarly affected by anoxia.

Kuznetsova (1950) connected the duodenum of a foal to the jejunum by means of rubber tubing. He found that 90-140 litres of chyme passed each day. This was a much greater volume than could be accounted for by ingested food and water. It should be noted with regard to this large volume of chyme that Colin (1886) found that a small horse eating hay secreted 5 kg. of saliva in an hour.

Although the cæcum and colon are the most important sites of fermentative digestion in the horse, even in ruminants these organs are not unimportant, about 30 per cent of the digestable cellulose in the diet being digested in the cæcum and colon (Gray, 1947). However, the mechanics of the ruminant large intestine have attracted little attention. Sporri and Ascher (1940) studied the movements of the cæcum and colon by introducing barium through a fistula in the cæcum of goats and making radiological observations. They observed mixing movements, peristalsis and anti-peristalsis in the cæcum and proximal colon, and peristalsis and segmentation in the spiral colon. Pellet formation was first noted in the caudal part of the spiral colon. The backward passage of barium through the ileo-cæcal opening into the ileum was also observed.

One of the main reasons for the lack of information on the functions of the large intestine of the horse has been the surgical problem presented in preparing permanent fistulæ into this organ. However, Alexander and Donald

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(1948) have described a method of fistulating the cæcum and large colon in ponies and this method has now been developed (Alexander, 1952) so that fistulæ can be produced in the cæcum, dorsal and ventral colons of the same horse. These techniques should greatly facilitate the study of digestion in the horse. Howell and Cupps (1950) have described experiments on a horse with a permanent fistula of the cæcum; they had no device for closing the fistula. These authors found that feeding increased cæcal movements. Alexander (1952) using unanæsthetised fistulated ponies has described three types of cæcal and colonic movement. He found withholding food greatly decreased motility in the cæcum and ventral colon but had little effect on the dorsal colon; there was no evidence of increased activity on feeding. Brunard and Dussardier (1952*b*) have recorded the movements of the cæcum in anæsthetised (chloralose) equines. They have described strong emptying contractions of this organ. However, their published tracings show a much slower rate of contraction than in tracings published by Howell and Cupps (1950) or Alexander (1952). Indeed, the tracings of Brunard and Dussardier resemble those from a fasting horse (Alexander, 1952). An explanation for this discrepancy might lie in some inhibitory mechanism operating in anæsthesia.

Innervation

The trend of evidence during the past twenty years has been towards the localisation of an area in the brain which controls the movements of the reticulo-rumen. Popov, Kudryavcen and Krasowsky (1933) showed the movements of the ruminant stomach to be dependent on an intact vagal supply. These workers exteriorised the vagi in the neck and observed that cessation of stomach movements was produced by cooling these exteriorised nerves. However, stimulation of the central end of the vagus nerve failed to cause rumination (Aggazzotti, 1910). Dukes and Sampson (1939) found stimulation of the peripheral vagus caused slow contractions of the omasum and characteristic contractions of the abomasum. Brunard and Dussardier (1951) studying the effect of vagal stimulation on gastric motility in chloralosed ruminants, found that stimulation caused contraction of the stomach, slowed the heart rate and lowered blood pressure. However, when acetylcholine, the accepted mediator of vagal stimulation, was injected intravenously it caused inhibition of gastric motility. The inhibitory effect of acetylcholine had been described earlier by Quin and van der Wath (1938). However, the related choline ester, carbamylcholine, and the choline esterase inhibitor, physostigmine, were found by Clark (1950) to increase ruminal activity. The reason for this conflict of evidence between the increased activity resulting from vagal stimulation and the inhibitory effect of acetylcholine is not clear. Brunard, Dussardier and Labouche (1950) found that acetylcholine caused contraction of strips of rumen and omasal muscle *in vitro* and Brunard and Dussardier (1951) showed that atropine inhibited the effect of vagal stimulation. This evidence they interpret as showing that a choline ester other than acetylcholine mediates the effect of vagal stimulation in the ruminant. However, since their evidence shows that the effect of

vagal stimulation is inhibited by atropine and that it resembles the direct action of acetylcholine on the stomach muscle, the most probable explanation of the inhibition produced by the injection of acetylcholine is that this is an indirect effect. Such an indirect effect might be caused by an interference with the blood flow to the stomachs or to a stimulation of the adrenal medulla causing an excessive secretion of adrenaline. It has been shown in the case of the horse that the effect of carbaminoylcholine and posterior pituitary extract on the movements of the ileum can be masked by their effects on circulation (Alexander, 1952).

Comline and Titchen (1951) found that splanchnic stimulation in decerebrate, spinal or chloralosed goats caused a small reticulum contraction and the intravenous injection of adrenaline had the same effect. Brunard and Dussardier (1951) found adrenaline and nor-adrenaline to act in a similar way although clear evidence has been obtained of the inhibition of reticulo-ruminal motivity by adrenaline in the unæsthetised animal (Duncan, 1951). Moreover, work on the horse has shown that adrenaline can cause either contraction or inhibition of ilial muscle depending on the oxygenation of the tissue (Alexander, 1949).

The earlier work on the innervation of the ruminant stomach has been described by Hoflund (1940) who himself worked extensively in this field. However, work during the past decade has repeated and extended these early observations. It is clear that the normal propulsive activity of the reticulo-rumen is dependent upon at least half of the vagal nerve supply remaining intact. Rumination and the œsophageal groove reflex are similarly dependent upon the vagus. Vagal section produces delayed emptying and dilation of the abomasum. The absence of movement in the reticulo-rumen following vagal section is unaffected by splanchnectomy (Duncan, 1953). Comline and Titchen recently (1951) made a detailed study of the œsophageal groove reflex using decerebate calves and lambs. They found that the superior laryngeal nerve was the only nerve of which stimulation consistently caused reflex contraction of the groove. The entry of water into the posterior part of the mouth was a more certain stimulus than nerve stimulation. The reflex was inhibited by stimulation of the central end of the abomasal nerve, this inhibition being independent of splanchnic innervation. They were unable to find any evidence of an inhibitory sympathetic innervation of the groove. Atropine abolished contraction of the groove resulting from reflex excitation or stimulation of the dorsal vagus. Reflex excitation was abolished by the intravenous injection of adrenaline and nor-adrenaline.

Duncan (1953) suggests that the reticulo-rumen, which represents the fundus of the primitive stomach, has developed an extrinsic nervous control. The reticulo-ruminal contractions are not intrinsic and are responses to rhythmic discharges from the brain stem caudal to the intercollicular plane (Clark, 1950; Iggo, 1951). Clark (1953) also showed that the cortex was unnecessary for rumination or movements of the reticulum and rumen; a subcortical area in the brain anterior to the pituitary infundibulum is concerned with these movements.

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THE VIRUS CONTENT OF THE TISSUES OF RABBITS INFECTED WITH RINDERPEST

By G. R. SCOTT, B.Sc., M.R.C.V.S.

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IT may be difficult to obtain an adequate supply of rabbits in tropical countries for the production of lapinized rinderpest vaccine. Hudson and Wongsongsarn (1950) overcame this problem in Thailand and passaged lapinized

virus in indigenous pigs and from these produced a satisfactory vaccine. The inoculation of cattle by the intradermal route was studied (Scott, 1952) and a considerable saving of vaccine was effected but the method was not considered suitable for African "inoculators." Attention has, therefore, been directed to the use of tissues other than spleen, mesenteric lymph gland and blood, from which lapinized rinderpest vaccine is at present made. Nakamura assayed the virus content of different rabbit tissues in 1941; an abstract but not his original paper was available when the present work began.

Materials and Methods

Virus Strains. The lapinized rinderpest virus used was the Nakamura III strain obtained through the courtesy of Dr. K. L. Kesteven of the Food and Agricultural Organisation from the National Bureau of Animal Industry, Nanking, China. At the time these experiments were begun the virus was in its 803rd passage.

Cattle were challenged with the Kabete "O" strain of virulent bovine virus, using 1.0 g. of spleen pulp, equivalent to 100,000 M.I.D.

Rabbits. These were $4\frac{1}{2}$ to 5 months old albino-rex crosses bred at the laboratory.

Cattle. High and medium grade European-Zebu cross steers were usually used.

Technique. Rabbits were inoculated intravenously with 1.0 ml. of a 1 :20 dilution prepared from dried virus and were killed between the 60th and 65th hour after injection. The different tissues were harvested separately and were weighed and broken down in a Waring Blendor or in a tissue grinder. Twenty per cent emulsions in normal saline were prepared and lyophilised, sealed *in vacuo* and stored at —20° C. to —40° C.

Dried tissues were weighed and ascending dilutions prepared in cold saline. Rabbits received 1.0 ml. intravenously and cattle 2.0 ml. subcutaneously of the respective dilutions. The restricted number of animals available precluded the estimation of 50 per cent end points by the method of Reed and Muench (1938). Temperatures were recorded twice daily. Rabbits were killed between the 60th and 90th hour after inoculation and examined for lesions of rinderpest. Cattle were challenged ten to fourteen days after inoculation.

Experimental

(i) *The virus content of rabbit tissues, titrated in rabbits.*

The data are summarised in Table I. The appendix, sacculus rotundus, Peyer's patches, spleen, mesenteric lymph gland and tonsilla cæcalis major were all rich in virus. The yield from the appendix was five times greater than from any other tissue. This high figure was unexpected and was carefully checked several times. The amount of virus demonstrable in dried blood was low. No virus was found in dried urine.

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(ii) *The virus content of rabbit tissues, titrated in cattle.*

These results are shown in Table I. The appendix, sacculus rotundus, Peyer's patches, mesenteric lymph gland, spleen and tonsilla cæcalis major conferred the most efficient immunity in cattle. This was fairly closely correlated to the virus content demonstrated by the rabbit titration method.

TABLE I

Infected Rabbit Tissues titrated in Rabbits and Cattle

Tissue	Highest Dilution Evoking Lesions in Rabbits	Highest Dilution Inducing Immunity in Cattle
Appendix	1 :50 millions	1 :80,000
Sacculus Rotundus	1 :10 millions	1 :20,000
Peyer's Patches	1 :10 millions	1 :20,000
Appendix plus the Sacculus Rotundus	1 :10 millions	1 :40,000
Mesenteric Gland	1 :1.5 millions	1 :20,000
Spleen	1 :1 million	1 :10,000
Tonsilla Cæcalis Major	1 :1 million	1 :10,000
Liver	1 :10,000	1 :500
Kidney	1 :1,000	1 :100
Lungs	1 :1,000	1 :500
Skeletal Muscle	1 :1,000	0
Blood	1 :100	1 :100
Brain	0	0
Urine	0	0
Bile	0	0

NOTE: O = virus not demonstrable.

(iii) *A comparison between the virus titres of fresh and dried rabbit blood.*

As shown in Table I, the amount of demonstrable virus in *dried* rabbit blood was small. Cheng and Fischman (1948) described the survival of lapinized virus in various diluents, including defibrinated rabbit blood, and considered the apparent superiority of the latter to be due to its virus content. This point was further investigated and citrated rabbit blood was titrated in rabbits immediately after collection and after lyophilisation. The seed viruses in this experiment had different histories.

Details are recorded in Table II. The titre of fresh blood was consistently high, but after drying, the same blood was negative or had a low virus titre. A number of trial batches of vaccine, in which physiological saline alone was added as a diluent (Table III), were examined and irregular titration results were obtained, whereas vaccine with blood consistently showed a high titre. It would appear, therefore, that the superiority of infected blood as a diluent is not solely due to its virus content.

TABLE II

A Comparison of the Virus Content of Fresh and Dried Infected Citrated Rabbit Blood

Accession No.	No. of Serial Passage	Highest Dilution Evoking Lesions Fresh	Dried
22.10.1	804	—	0
114	811	<1 : 10,000	1 : 1
111	811	—	1 : 10
113	811	<1 : 100,000	1 : 100
140	804	<1 : 100,000	0
4. 3.2	804	<1 : 10,000	1 : 100
160	807	<1 : 100,000	1 : 100
14. 5.2	807	<1 : 100,000	0
17. 5.2	808	<1 : 100,000	1 : 100
166	809	<1 : 100,000	1 : 100

0 = no virus demonstrable; < = end point not determined.

(iv) *Titration in rabbits of fresh and dried urine.*

The failure to demonstrate virus (Table I) in dried urine was unexpected. Accordingly, fresh and dried urine from rabbits inoculated with different seed viruses was titrated. The results were all negative.

(v) *The action of bile on lapinized rinderpest virus vaccine.*

Virus was not found in bile from infected rabbits (Table I). The mean

TABLE III

Titrations in Rabbits of Vaccines diluted before drying with (a) *infected blood, and* (b) *normal saline*

Accession No.	No. of Serial Passage	Highest Dilution Evoking Lesions Blood	Saline
111	811	—	>1 : 100
126	804	1 : 2 millions	1 : 1 million
147	804	1 : 1 million	1 : 1,000
158	806	<1 : 1 million	>1 : 100
160	807	1 : 1 million	—
21. 4.2	806	1 : 1 million	>1 : 1,000
13. 5.2	808	<1 : 1 million	—
14. 5.2	807	<1 : 1 million	—
164	809	<1 : 1 million	—
165	805	<1 : 1 million	—
166	809	<1 : 10 millions	—

< = end point not determined; > = less than.

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weights of infected rabbit tissues are recorded in Table IV, and, of the tissues investigated, the liver was the heaviest. It is difficult to remove a complete liver without contaminating it with bile. The effect of bile on lapinized rinderpest vaccine was, therefore, studied. It was found that the addition of an equal amount of either normal or infected bile to the fluid vaccine before drying killed the virus. In all, nine vaccines were tested and the addition of normal bile and of infected bile reduced their activity from over one in a million to below the level at which virus could be demonstrated.

TABLE IV

Tissues from Infected Rabbits titrated in Rabbits and Cattle

Tissue	Greatest number of infective (rabbit) and protective (cattle) doses per gramme or dried tissue	
	Rabbit	Cattle
Appendix	50 millions	40,000
Sacculus Rotundus	10 millions	10,000
Appendix plus Sacculus Rotundus	10 millions	20,000
Peyer's Patches	10 millions	10,000
Mesenteric Gland	1.5 million	10,000
Spleen	1 million	5,000
Tonsilla Cæcalis Major	1 million	5,000
Liver	10,000	250
Kidney	1,000	50
Lungs	1,000	250
Skeletal Muscle	1,000	0
Blood	100	50
Brain	0	0
Urine	0	0
Bile	0	0

NOTE: O = no virus demonstrable.

Discussion

The appendix, sacculus rotundus, Peyer's patches, spleen, mesenteric lymph gland and the tonsilla cæcalis major of the rabbit contain the highest concentrations of rinderpest virus after inoculation, and immunised cattle effectively.

The virus titres of rabbit spleen and of mesenteric lymph gland were high after they had been emulsified separately in normal saline and lyophilised. These two tissues were mixed together in normal saline and the virus content of the dried mixture was inconstant. This variation was prevented when citrated rabbit blood was used as a diluent and the explanation for this phenomenon is being investigated. Thus, although Cheng and Fischman's (1948) original observation that defibrinated infected rabbit blood is a better diluent than either physiological saline or phosphate buffer holds good, the superiority of rabbit blood

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appears to be due to a biochemical action and not to its virus content; this is low after drying.

The average yield of spleen and mesenteric lymph gland from one infected rabbit is 4.0 g. The addition of liver is likely to be dangerous because of the risk of bile contamination. The mean weight of the infected appendix was 4.8 g. so that its incorporation would double the weight of harvest per rabbit, and since each gram of dried appendix contains 50 million M.I.D's for rabbits, the resultant dried product could be expected to be richer in virus. This possibility is at present under investigation.

Summary

The virus content of rabbit tissues infected with rinderpest has been estimated and the immunological efficiency in cattle of the dried tissues has been examined.

The significance of infected rabbit blood as a diluent in lapinized rinderpest virus vaccine is discussed.

Acknowledgments

I have to thank Dr. S. E. Piercy, Chief Veterinary Research Officer, for helpful advice and criticism, and Mr. R. A. Hammond, Director of Veterinary Services, for permission to publish this article.

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INCIDENCE OF DISEASES AND MORTALITY AMONG THE EGYPTIAN CATTLE AND BUFFALOES

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The Egyptian cattle and buffaloes belong to the same genus. Egyptian cattle are a mixture of both *Bos indicus* and *Bos taurus,* the Egyptian buffaloes are *Bos bubalis.*

Instances of differential resistance to diseases or parasites have been noted. Hagedoorn (1947) stated that natural immunity to disease can be found more often in land-races than in highly improved breeds. Pucci (1915) recorded that the zebu is immune to foot-and-mouth disease and this also occurs with the first generation produced by mating zebu with certain Italian and Swiss cattle. Crew (1925) stated that in the Philippines, the zebu shows complete immunity

to rinderpest and tick fever. The zebu is used in Texas because of its relatively greater resistance to tick fever than the European breeds (Rice, 1934).

Hutyra, *et al.* (1938) pointed out that buffaloes like cattle are susceptible to tick fever. They also stated that rinderpest infection occurs principally in cattle and most outbreaks of the disease are limited to this species. In Bulgaria, the same authors reported that the incidence of tuberculosis was less in buffaloes than in cattle.

As far as milk production is concerned, El-Sokkary and Hassan (1949) found that the milk of Eygptian buffaloes had significantly higher percentage of fat, non-fatty solids, total nitrogen and casein nitrogen than the milk of Egyptian cows. Badreldin (unpublished data) stated that Egyptian buffaloes are better adapted to withstand high atmospheric temperatures when kept indoors than Egyptian cattle. The purpose of the present study was to investigate the comparative susceptibility to disease and the mortality rate among the Egyptian cattle and buffaloes.

Materials and Methods

A total of 394 Egyptian cattle and 261 Egyptian buffaloes were included in the present study. They were kept on the farm of the Animal Nutrition Department, Faculty of Agriculture, Giza, during the period 1943-1952. The incidence of the infectious and the non-infectious diseases and the mortality were recorded along with their respective percentages to the total number. The statistical significance of the data was tested by the X_2 test (Snedecer, 1946).

Results and Discussion

The incidence of disease and mortality varied from year to year in both cattle and buffaloes (Table 1). The average percentage of diseased animals

TABLE I.

Incidence of Disease and Mortality in Egyptian Cattle and Buffaloes during the period 1943 to 1952

Year	Cattle					Buffaloes				
	Total	Animals Diseased		Mortality		Total	Animals Diseased		Mortality	
	No.	No.	%	No.	%	No.	No.	%	No.	%
1943	35	26	74.2	8	22.9	21	12	57.1	2	9.5
1944	40	29	72.5	6	15.0	24	15	62.5	2	8.3
1945	43	32	74.2	5	11.6	36	19	52.8	5	13.8
1946	38	23	60.5	4	10.5	28	10	35.0	4	14.3
1947	40	27	67.5	4	10.0	24	14	58.3	3	12.5
1948	38	26	68.4	3	7.4	22	10	45.4	3	13.6
1949	44	28	62.7	6	13.6	19	11	57.8	4	21.1
1950	42	18	42.8	8	18.9	17	8	47.1	3	17.6
1951	43	36	83.7	2	4.6	22	11	50.0	3	13.6
1952	31	20	64.5	2	6.5	48	23	47.9	2	4.2
Total	394	265	67.26	48	12.18	261	133	50.95	31	11.87

was 67.26 in cattle, and 50.95 in buffaloes. The difference between the incidence of disease in both species was highly significant (p=less than 0.01). The average mortality rate was about the same in cattle and buffaloes (12.18 and 11.87 per cent respectively); the difference was not significant. Of the non-infectious diseases, enteritis and pneumonia were the most important causes of death (Table II). Some infectious diseases encountered during the

TABLE II.

Cases of Non-Infectious Disease and the Mortality in Egyptian Cattle and Buffaloes during the years 1943 to 1952

	Number of Diseased Animals		Number of Dead Animals	
	Cattle	Buffaloes	Cattle	Buffaloes
Pneumonia	28	5	8	3
Enteritis	29	22	14	13
Impaction and Tympanites	28	23	1	2
Indigestion	20	13	—	—
Ascites and Debility ...	6	9	3	4
Metritis and Retention of Placenta	24	14	2	2
Mastitis	20	11	—	—
Uræmia	—	—	4	2
Jaundice	8	3	2	—
Pyæmia	—	—	2	3
Mange	4	9	—	—
Conjunctivitis	6	3	—	—
Lameness	24	7	—	—
Wounds and Abscesses ...	21	5	—	—
Fractures	4	1	—	—
Total	222	125	36	29

TABLE III.

Cases of Infectious Disease and Mortality in Egyptian Cattle and Buffaloes during the years 1943 to 1952

	Number of Diseased Animals		Number of Dead Animals	
	Cattle	Buffaloes	Cattle	Buffaloes
Foot-and-Mouth Disease (in 1944, 1949) ...				
Texas Fever (in 1945) ...	18	4	6	1
Cattle Plague (in 1946) ...	7	—	1	—
Stiff Sickness (in 1951) ...	1	—	1	—
Tuberculosis (in 1944,	9	2	1	—
1949, 1951 and 1952)	8	2	3	1
Total	43	8	12	2

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last ten years were: foot-and-mouth disease (in 1944 and 1949), Texas fever (in 1945), cattle plague (in 1946), stiff sickness (in 1951) and tuberculosis (in 1944, 1949, 1951 and 1952). While the cattle were susceptible to the above-mentioned infectious diseases, there were no cases of cattle plague or Texas fever among the buffaloes (Table III).

From the records of the incidence of the diseases and deaths, the buffaloes seemed to be less susceptible than cattle. They were immune to both cattle plague and tick fever. This is in agreement with Hutyra, *et al.* (1938). Since butterfat in Egypt is the main source of fat for cooking, and because the milk of buffaloes has a much higher percentage of butterfat than the milk of cattle, the keeping of buffaloes is preferred. It could be concluded from these figures and from the previous investigations on production and adaptability that buffaloes are suited better than cattle to Egyptian conditions.

Summary

1. A total of 394 Egyptian cattle and 261 Egyptian buffaloes were under observation during the years 1943 to 1952.

2. The incidence of disease was significantly higher in cattle than in buffaloes.

3. The mortality rate was about the same in both species.

4. It is concluded that in Egypt buffaloes may be preferred to cattle, because they are not so susceptible to disease.

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REVIEWS

ADAPTATION IN MICRO-ORGANISMS. Third Symposium of the Society for General Microbiology held at the Royal Institution, London, 1953. Edited by E. F. Gale and R. Davies. London: Cambridge University Press. Price 30s. net.

THE committee of the Society for General Microbiology invited a number of authorities to submit contributions, under the general title of "Adaptation in Micro-organisms." These contributions form the main part of this book; the discussions, which took place at the meetings in April, 1953, have been constructed by the editors from the material which each speaker was asked to forward after the meetings. The general account is thus a very full one and in spite

of the loss of the spontaneity of the discussion, there is this compensation, that neat and concise replies, often with references to the literature appear instead.

The general subject of adaptation has been dealt with at an advanced level and the contributions will prove of interest to microbiologists, biochemists, geneticists, and to all biologists who are interested in the evolution of living organisms. When living organisms move from one environment to another they may have to undergo considerable changes in order to continue and to multiply. They "adapt" themselves, if they meet satisfactorily these challenges, and as micro-organisms are found in a wide range of conditions, they may be subject to a wide range of change. Consequently they provide excellent material for the investigation of the nature and mechanism of adaptation.

Adaptation is indeed a biological axiom and includes the many processes of change which confer upon an organism the ability to survive and grow and multiply in its environment. In heterogeneous populations, which contain organisms capable and incapable of adaptation to an environment, there are two processes. There is a selection of those organisms which are capable of adaptation and there is, at the same time, the induction of those biochemical reactions underlying adaptation. Both processes are probably always operating in adaptation experiments; genetic principles must be taken into account in the experimental analysis as well as a change in enzyme constitution. The present knowledge on the question of the precursor which is converted into active enzyme was discussed and it is obvious that much is still obscure, especially of the mechanism whereby free amino-acids serve as precursors. It is also important to note that some enzymes may be induced by substances that are not present as such in the medium in which bacteria grow, but arise as intermediates in the metabolism of other substances.

The evolution of living organisms is a study which has quickened the interest of all manner of scientists; the biochemist plays a great part in that study to-day but the contributions given herewith will be of interest to a wider public.

THE STORY OF COBALT DEFICIENCY IN ANIMAL HEALTH, by C. S. M. Hopkirk, D.V.Sc., and J. B. E. Patterson, M.Sc., F.R.I.C. Published by Mond Nickel Company, London.

THIS admirable little monograph is the result of a collaboration between a veterinary surgeon and a chemist, both of whom have had first-hand acquaintance with the problem they have so well described. The monograph is quite short—twenty pages plus six pages of references, and no veterinary surgeon could claim that he is too busy to have time to read the monograph, or too well versed in the subject to be able to profit from it.

In the first section of the book, a very useful historical account of the effects of cobalt deficiency on animal health is provided. This section merits careful reading by all veterinary surgeons, for it illustrates the delays which may follow the application of "practical" or empirical methods rather than the scientific approach to disease. The historical account is followed by a description of the significance of cobalt in metabolism, full attention being paid to the relation-

ship between inorganic-cobalt and the cobalt-containing vitamin B_{12}. The monograph is not parochial in its outlook, for it presents a world wide survey in a beautifully condensed form. In addition to an account of the evidence of severe cobalt deficiency, paragraphs are devoted to sub-clinical evidence, and to notes on medication.

The authors believe that their review is impartial and is limited to reasonably well-established facts. One can agree with this claim and can heartily recommend the monograph.

BEEF CATTLE HUSBANDRY, by Allan Fraser, M.D., D.Sc. London: Crosby Lockwood and Son, Ltd. Price 18s. net.

THERE can be no doubt that the best beef comes from cattle that have been bred and reared for beef production. Britain was the first country to adopt this type of stock husbandry and the various breeds which are famous in this respect in all parts of the world originated in these islands. It may come as a surprise to some that this great industry has been in existence only for about 200 years. It originated in the late 18th century when for economic reasons the horse displaced the ox in transport and traction. The horse has been displaced, and there are those who think that the future economy of our farms could be served best if the ox resumed his traditional place at the plough and worked for his living until the time came for him to add to the store of beef.

A 100 years ago, Britain could supply all her own requirements of beef, but as the industrial revolution got under way and the population increased with great rapidity, the eyes of the meat salesmen were cast overseas to the cattle ranges in the Americas and Australia. Science and refrigeration brought this meat to our doors and the growing demand for milk and milk products made our farmers turn to the dairy for economic survival. The best and choicest beef was still home grown, it commanded a high price and fortunately the economic rewards were sufficient to encourage our breeders to continue their efforts to produce the best beef cattle in the world

A new market arose for the foreign breeders, and rearers were quick to realise that British stock was the best foundation on which to build their herds. Britain became the beef stock nursery of the world. After two world wars the international financial pendulum has swayed against us and we have to look more and more to our own fields.

In this book Allan Fraser tells us how this can be done and how we can get the best return and quality. He discusses beef and beef quality and the breeds that are the best primary producers. He explains the methods and reasons for beef grading. He gives much valuable information on dual-purpose cattle and on hill cattle and how they can be utilised to advantage.

He tells us of potential sources of beef on our hill and marginal lands and from our dairy herds. There are chapters on cattle rearing and on summer and winter fattening which can be read with profit and interest by the experts.

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In the final chapter he reviews the future policy on beef production. It is doubtful if concentrates will be available in sufficient amount or at an economic price to make the pre-war methods of producing quickly maturing "baby" beef economically possible. The changes in our social habits may help. The growth of communal feeding in restaurant and canteen calls for the larger joint from the beast of full maturity. The heavier and more mature grass-fed beast is better suited therefore to modern conditions. There are four or five million acres of rough grazing available but to make full use of the beef that might be produced, slaughtering and refrigerating facilities must be improved and increased. There is no doubt that grass is the cheapest food for beef cattle. It is in most ample supply in the spring and summer. If storage facilities were adequate dangerous seasonal gluts and shortages could be levelled out.

There are many excellent illustrations and an extensive reference table at the end of each chapter. We can recommend this book to all those who are concerned with animal husbandry.

OBITUARY

FEBRUARY 20—at 11 Kingsmead, Upton-by-Chester, Edward Francis Wood, M.R.C.V.S., aged 82. Late of Hooton, Cheshire.

PREPARATIONS AND APPLIANCES

ALLEN & HANBURYS, LTD. announce the introduction of Entavet, an oral preparation of Streptomycin and Sulphaguanidine for the treatment of calf scours, diarrhœa of dogs and cats and enteritis of swine. It is supplied in bottles as a dry powder from which four fluid ounces of suspension may be prepared by the addition of cold water. The manufacturers will be pleased to send full particulars.

INTERESTING developments have resulted from the introduction of Tubegauz in this country. This revolutionary form of bandaging first invented by an American chiropodist has been taken up and sponsored by the Scholl Foot Comfort Service. It has been widely accepted in British hospitals for all types of bandaging. Tubegauz is now welcomed by veterinary surgeons who have found that it is a bandage which will stay put on a cat's leg. Race-horse trainers in this country and Europe are employing it for the fetlocks of horses. Further information may be obtained from the Scholl Manufacturing Company, St. John's Road, London, E.C.1.

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NOTICES

THE Distillers Company (Biochemicals) Ltd., Speke, Liverpool, 19, on behalf of its distributors: Allen and Hanburys Ltd., The British Drug Houses Ltd., Burroughs Wellcome and Co., Evans Medical Supplies Ltd., Imperial Chemical (Pharmaceuticals) Ltd., and Pharmaceutical Specialities (May and Baker) Ltd., announces reduced retail prices from March 29 for their products: *Penicillin G,* Sodium Salt and Potassium Salt (Buffered); *'Distaquaine' G*; *'Distaquaine' Fortified*; *'Distaquaine' Suspension.* Full details may be obtained from any of the above firms.

BAYER PRODUCTS LTD. announces replacement of the 25 c.c. with a 30 c.c. packing of "Hepmin," with an accompanying percentage increase of the Vitamin B_{12} content.

The proportion of Vitamin B_{12} has been increased from 12 micrograms to 50 micrograms per c.c. at the time of preparation, and the manufacturers claim that "Hepmin" represents a most convenient means of administering therapeutic doses of liver, iron, trace elements and Vitamin B_{12}, in single injections.

Errata

The following errors appeared in the text of the article by A. Brownlee—"Play in Domestic Cattle in Britain" in February issue of the Journal.

Page 60. Third paragraph, line 2. Read: "Under the influence of its drive, receptory correlates recognise and accept as valent . . ."

Page 66. Third paragraph, line 14: "Walton also states (and I agree with him) that œstrous, diœstrus and pregnant cows will mount an œstrous female. The question thus arises whether mounting by castrated males . . ."

Acknowledgment

We were indebted to Dr. J. K. Gan of the Royal Veterinary College, London, for the Memoir of Florence Rena Sabin which appeared in our March, 1954 issue.

Publishers' Notices

THE BRITISH VETERINARY JOURNAL, with which is incorporated THE VETERINARY JOURNAL, is published monthly, and copy for advertisements should be in the hands of the advertisement manager not later than the 20th of the preceding month, if proof is required. Tel.: Temple Bar 3386.

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